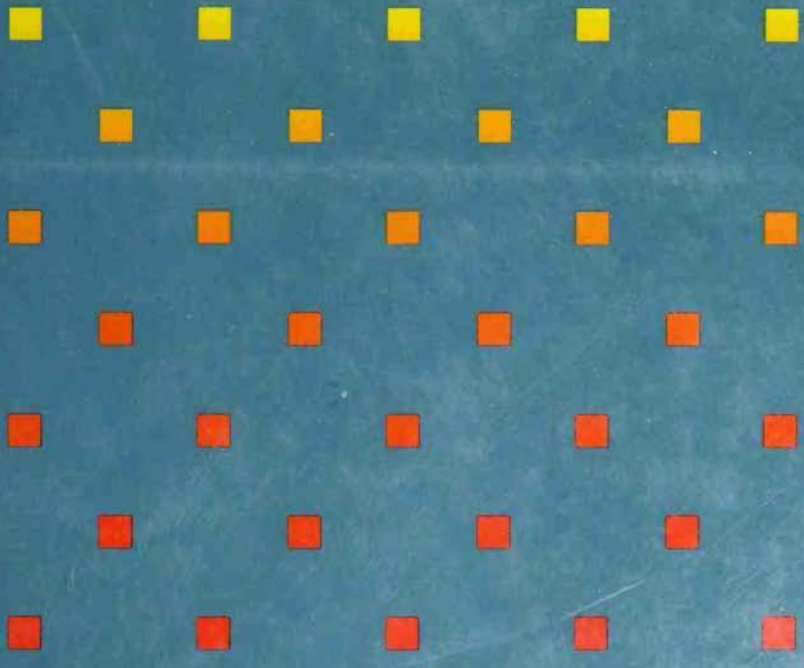
Taiichi Ohno



WORKPLACE MANAGEMENT

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Workplace Management

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▼

Taiichi Ohno

TRANSLATED BY ANDREW P. DILLON

Foreword by
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Publisher's Foreword

TAIICHI OHNO IS the recognized father of the Toyota production system, the manufacturing method Westerners know more commonly as just-in-time (JIT) — that is, producing the exact product needed in the exact quantity needed at the exact time needed by the customer.

Mr. Ohno's principles are completely changing the way we manufacture goods and deliver services. No longer must we accept the restraints of economic order quantity (EOQ) theories; nor must we accept the scrap, defects, or long set-up times as givens. No longer is there a reason to see customers as "them" versus "us"; no longer a reason to treat a human being as an extension of a machine.

In October 1987, two of Mr. Ohno's premier students, now visiting consultants from Japan — Mr. Yoshiki Iwata and Mr. Chihiro Nakao — spent a day at a manufacturing plant in North Carolina. I asked the plant manager to tell me what happened. His reply:

> It was the best experience of my life. It was stunning. They completely motivated everyone towards improvement. In one day, they cut set-up times in half on two machines. It was amazing to watch them in action. They communicated better in Japanese to our workers than we do in English. But what I admired most was their incredible respect for humanity.

The Toyota system is not just an inventory reduction system. It is a new way of doing business in the world. In the past, companies could live with lead times of weeks if not months. Today, on the other hand, a world-class company requires lead times of days, if not hours, to respond to cus-

tomer needs. Daily improvements coupled with the involvement of all employees and top management is Ohno's road to manufacturing success in the world.

In his first book, *Toyota Production System: Beyond Large-Scale Production* (Cambridge, Massachusetts: Productivity Press, 1988), Mr. Ohno explains the development of his principles and philosophy through the years. *Workplace Management* presents the author's broad philosophy of life in the workplace — in the office as well as on the production floor. The simplicity of his teachings takes away the mystery surrounding the miracle of Japanese management.

Mr. Ohno drew much from the writings of Henry Ford and was amazed at the implications he felt Americans had ignored in Ford's ideas. Building on these ideas, Mr. Ohno more than any other person is responsible for the incredible growth of Japanese industry. I have enjoyed learning how Mr. Ohno thinks and I am sure everyone will find their journey through these pages fascinating.

I want to thank Mr. Ohno and the Japan Management Association for allowing us to publish *Workplace Management* in English. I want to thank Andrew P. Dillon, the book's translator, and Cheryl Berling Rosen, the book's editor, for their devotion to the integrity of Mr. Ohno's words. Thanks also to all the others at Productivity Press and Rudra Press for doing such an excellent job in delivering this fine book to the American reader.

Norman Bodek

Preface

WITH THE GENEROUS assistance of the Toyota Motor Corporation, I first became involved directly in automobile manufacturing in February 1945, 37 years ago.

I see now that automobile manufacturing then was a completely different world. Working in production shops over the course of the intervening years, I have witnessed a progress that seems to me to have been perfectly natural. At the same time I realize what a struggle it has been.

As we contemplate the next 10 or 20 years, however, we cannot indulge in sentimentality, because the future is sure to hold unimaginable changes. What is past is past. I think the important thing now is the present and the means to transcend it. Comparing the present to the past is meaningless.

I seem to be known as the father of the Toyota production system, or the creator of the *kanban* system, and it is true that for a while I worked, on a trial-and-error basis, with an innovative approach to manufacturing called the Ohno System. But the real credit for building the present-day Toyota production system rests squarely with Toyoda Eiji, president of the company, the late Saitō Naoichi, a Toyota consultant, and the gritty determination with which so many people in the workplace cooperated with what I had to say.

The Toyota production system can be summed up in a single phrase — "Make only what you need, in the quantities you need, when you need it." This makes perfect sense when you think about it. What makes the goal so hard to attain is that old habits and methods prevent us from changing our thinking and our behavior.

With the hope that my experiences may be of some value to others, I finished compiling this book in 1982, a year in

which, in the spring, I was quite unexpectedly awarded the Order of the Rising Sun, Third Class, and which marks more than 30 years since Toyota Jikō and Toyota Jihan merged to form Toyota Motors. The writing may be a bit careless in places, but I will be satisfied if the book at least serves to provide some hints for breaking through misconceptions and illusions.

This volume came into being at the urging of people at the Japan Management Association and especially of its president, Mr. Jūji Masa. I would like to take this opportunity to express my gratitude to them all.

Taiichi Ohno
September 1982

A Note on Japanese Names

IN JAPANESE, the family name appears first. Thus, the famed inventor of the Toyota production system is known in Japan as Ōno Taiichi, and not Taiichi Ohno as usually written in the West.

In Productivity Press books we try to follow the Japanese practice of placing the surname first, in part, to make the representation of Japanese names uniform but primarily out of common courtesy. The reader therefore will find members of the Toyoda family referred to as Toyoda Sakichi, Toyoda Kiichirō, Toyoda Eiji, and so forth. However, when a person such as Taiichi Ohno is frequently referred to in other Western publications and the media in the Western manner, we refer to him or her likewise.

Also, when romanizing Japanese characters, a macron is used over a long vowel in all Japanese words except for well-known place names (Kyoto, Tokyo), words that have entered the English language (shogun, daimyo), and individual's names in which customarily the macron is replaced by an *h* (Ohno, not Ōno).

Workplace Management

1

The superior person knows how to adapt

I have been asked to write about "workplace management," but I do not feel confident enough to discuss the topic in a systematic way. I would rather talk about some ideas that are of primary importance to me.

I am not of the opinion that subtle or gentle actions will set the workplace in motion right away. Life would be simple indeed if things moved constantly — but that is not the way the workplace operates. If you want change, you really have to persuade people first, bringing them around to your way of thinking.

To bring people around through persuasion, you should have something to back up what you are saying. Otherwise, most people will not be moved. I have been asked in many forums how one goes about persuading people, and I think to a certain extent you must have a certain amount of self-confidence when giving instructions or orders to others. Yet even with self-confidence, the mind of a man or woman is such an uncertain thing that perhaps we should be happy if as much as half of what we say is true.

In Japan we have an old proverb that says even a thief is right one-third of the time. If a thief can be right a third of the time, then the average man or woman ought to be able to be right half the time. It seems to me, however, that we should accept that we are going to be wrong the rest of the time.

When I was a middle-school student under the old prewar educational system, we had a class in reading classical Chinese. In the *Analects*, Confucius says that "the superior man knows how to adapt" and "the superior man does not fear change." Now, the term "superior man" seems to refer

to a pretty admirable kind of person, the sort who says the right thing more than half of the time. Yet the point of saying that such a person "does not fear change" or "knows how to adapt" is that not even a superior person will be right 100 percent of the time.

Even a superior person who is right 70 percent of the time cannot avoid being wrong about three times out of 10. Though wrong, however, that person does not fear being corrected. I am saying that the leopard should not be afraid to change his spots. The saying means that though you stubbornly insist that everything coming out of your mouth is correct, this may simply not be so.

Another old expression we learned was: "Don't issue orders in the morning and repeal them that evening." According to my somewhat unreliable memory of the time, we were taught to avoid the wavering shown by giving commands or instructions in the morning and then changing them the same evening. Yet it seems to me that the superior person who knows how to adapt and does not fear change *should* issue orders in the morning and repeal them in the evening.

If the orders you issue in the morning are hazy and equivocal in the first place, then perhaps they should not be changed until you see their results. Yet once you issue an order, why wait until later if the results lead you to think you have made a mistake? Why *not* issue orders in the morning and repeal them the same evening? You need to run things in such a way that you can change or repeal them even in the afternoon. Yet in some countries, once laws and ordinances have been enacted, they are left in effect rather than changed. Indeed, in some places you can hear people exclaim, "What? You mean that rule is still on the books?"

There may well be a fair number of countries in the world that, for better or worse, leave laws in effect for years because it would be unacceptable "to issue orders in the morning and then repeal them in the evening." As customary as this thinking seems to have become, there is no reason for your own company to be content with it.

Technicians are especially prone to stick by what they themselves have said or thought. Yet despite their reputation for thick-headedness or stubbornness, it is important for technicians to see themselves as superior people who can easily adapt to change. If you realize that something you have said is wrong, admit it. Otherwise, subordinates or others in the workplace will not follow you. Humans are always going to make mistakes. So isn't it then natural to apologize to subordinates for one's own errors? It seems to me that frankness of this sort will eventually have an effect on persuasiveness.

If, out of fear of someone, you go along with things just to be doing something — even though you suspect it to be wrong — the negative impact will grow and grow, and you will never understand how bad things really are. Whenever you decide that conditions are not right for making a change, you end up with a rule that is on the books forever. Do that, and other people will eventually stop listening to you.

We are all human and as much as half of what we do is mistaken; managers may sometimes even tell subordinates things that are wrong. The people managers deal with will gradually begin to turn away unless those managers first adopt the attitude that those under them are human beings, too — and that at least half of what their subordinates say is right.

It seems to me, in short, that the development of this sort of personal humility is an essential condition for building solid powers of persuasion.

2

If you
are wrong,
admit it!

Why are we wrong half the time, we might ask? Even when we speak with great confidence, our basic conceptual approach is often in error.

Language provides us with the word "illusion," implying the sense of sight or something visual. For example, if we arrange two lines of the same length to form an inverted T as shown in the figure ⊥ the vertical line will invariably appear longer than the horizontal line. This elementary example is often used in explaining illusions. The basis for error lies in assuming that one line is longer than the other because it *looks* longer.

As long as the lines are in this configuration, one will always look longer than the other. To prove that the lines are really the same length, we have to break apart the inverted T and place the lines side by side. Visual illusions of this sort are easy to explain because it is easy to convince people that neither line is longer than the other.

The lines may appear to be a certain length, but you cannot tell how long they are with respect to how long they appear just by looking at them. In the final analysis, you cannot tell unless you place the lines parallel to each other for comparison.

Similarly, many things in the world cannot be understood without trying them out. Indeed, a surprising number of things, when tried, yield results that are exactly opposite to what one expects. This shows us how inescapably dogged by illusion humanity really is. It is quite easy to dispel visual illusions by putting such illusions to the test. A little experimentation in such cases will suffice to persuade people. Illusions involving mental processes, however, are much more difficult to overcome.

Since human beings labor under illusions, we should be happy if half of our instructions or orders are correct. In olden times, Confucius surely knew that we were wrong half the time — perhaps that is what allowed him to say that the superior man does not fear change.

In the final analysis, there are always some people who persuade themselves on the basis of illusion that one line is longer than the other. Even if you tell them the lines are the same length, they will not believe you. They have to test the idea themselves. Having verified it, some may regret having made others act on ideas they once thought were correct. Others may continue to have workers on the shop floor test various ideas so that they too can recognize illusions.

When allowing people to try out an idea, the person who gave the instructions in the first place should be present to follow the results closely. If the idea does turn out to be a mistake, then the fact that the error is witnessed firsthand will have an effect on the workers. They will realize that since the boss apologizes when he or she makes a mistake, they as workers can feel freer to experiment with whatever ideas might occur to them.

On the other hand, wouldn't workers be even more cooperative when mistakes are met, not with reproving looks, but with encouragement and the explicit recognition that only five out of 10 ideas that you yourself come up with are right? When workers start thinking that they have to keep quiet and stick with whatever the boss tells them to do, for better or worse, they will gradually stop listening.

In the end, persuasiveness comes when both command-giver and doer see each other as human and only right half the time. Even if one party is tempted to say "I told you so," the other will not take it amiss. In fact, both will begin to cooperate before long. This, I believe, is true persuasiveness. If humans were not prey to illusions, then there would be no need for persuasion. Illusions involving people's unspoken thoughts yield only grudgingly to persuasion. It seems to me, also, that the more of an intellectual you are, the more likely you will succumb to illusions.

3

Illusions lower efficiency

In the workplace, ideas can be tested right away. For example — and I think this is true just about everywhere — it is thought that doing things in batches allows you to do them more quickly. The idea is that it is extremely inefficient to have someone handle one item at a time. People are convinced that efficiency and productivity improve when they repeat the same thing over and over.

I once observed the way a woman performed an inspection task. She took a number of items, lined them up, and then inspected them. She would not listen, no matter how often I pointed out that it would be easier and more efficient to take each item as it came off the line, inspect it, and then pack it in a box.

"Look," I said, "your method is fine. But, just once, why not do them one by one, the way I'm suggesting? I know it's a little tedious, but I think you'll be able to inspect more pieces with my method."

I had her try out the new idea for a day — a day in which she normally would not be able to inspect 5,000 pieces without running into overtime. By doing one piece every 20 seconds, she was able to do 5,000 pieces during regular hours. Even so, she could hardly believe such a relaxed method could result in such efficiency.

I suppose it is natural to succumb to the illusion that more work is done if you busily gather pieces into lots, take 20 or 30 in one hand, and line them up in neat rows. But what happens if, as described, you inspect the items one by one? It is more like play than work. And if you play around with it and find that you finish during regular work hours, it means

no overtime and less pay. So, while the idea seemed fine to me, it turned out to be a loss for the worker.

Inspecting the items one by one, however, made the task more relaxed and less tiring. What is more, the worker could accomplish the same quantity of piece work as before without going into overtime. After trying the new method, she was won over. This involved a relatively simple approach. Yet, surprisingly, simple approaches like this are often not put into practice in the workplace.

Let me tell you an old story from the postwar years, a story that takes place at Toyota Jikō. The job was to drill holes into round rods — that is all we wanted to do. Now, it happened that this operation was expected to turn out 80 rods a day. A young worker fed the rods manually into the machine where the holes would be drilled. But why feed them by hand? Why not leave out the manual part of the operation so the worker could relax while the holes were being drilled?

Well, somehow, feeding the rods by hand seemed faster. If we fed them in automatically, the bits would break off, lose their edge, and produce defective holes. The objection to automatic feeding was that you could tell how well the bit was cutting when you fed the rods by hand. Therefore, manual feeding was faster.

So I asked the worker, "How long does it take to drill each hole?"

"About 30 seconds," he replied.

"Thirty seconds?" I said. "That means you could drill two per minute, doesn't it?"

The worker nodded.

"In an hour, then, you could drill 120 rods," I continued. But this time the worker did not respond. Why?

"I'm drilling these rods by hand," he had said, "and because I work like the dickens I can do 80 a day."

Now, however, the suggestion was that, with 60 minutes in an hour, he could drill 120 rods an hour. He stopped answering me because it was awkward being told that he could drill 120 rods per hour, when he had boasted about

being able to drill 80 rods in 7 hours. Why would he need 7 hours to do 80 rods when he ought to be able to do that many in 40 minutes? That would mean that he was only doing 40 minutes of work a day!

"Look here," he said. "I'm working my tail off. What are you complaining about?"

"It doesn't matter how hard you're working or how much sweat you're putting into the job." I said, "You're still only drilling 80 holes in 7 hours. Maybe we should just have you come to work for an hour every day."

"Don't be ridiculous!" he replied.

Let's think about this. If somebody is drilling by hand as fast as he can, he will have the impression that he is working quickly. Automatic feeding would take 40 seconds, but he can do it by hand in about 30 seconds. So he concludes that it is more efficient by hand. If he continues at that pace, however, the drill bit will overheat, lose its edge, and not cut as well. He must then take the bit to a grinder and re-hone the edge. He brings it back and drills about three more holes. Then the bit overheats and goes bad on him again. After two or three more holes he must re-grind the bit again, an operation he considers part of the job. He thinks that by really working at it, he can drill a hole in 30 seconds. But he is deluded when he assumes that continuing at the same pace will improve efficiency.

If he had to drill 80 holes per day with automatic feed, however, he would only have to process one rod every 5 or 10 minutes. Ideally, an appropriate cutting speed would allow him to drill a hole in 40 seconds, leaving 4 minutes and 20 seconds for the bit to cool down. The unit would again be at room temperature when it came time to drill the second hole. Whenever the bit gets a little too hot, you can either put it aside for 4 minutes or apply cutting oil to cool it down to the temperature of the oil. This permits a bit that used to be sharpened between every hole to hold its edge for 30 or 50 rods.

What's more, workers do not have their own whetstones. There is one whetstone with five or six people lined

up to use it, each going through pretty much the same procedure. Lathe bits, for example, may also be used to the utmost — which means that they, too, will lose their edge quickly — so workers who have to grind lathe bits will be lined up at the whetstone as well. So, even if in theory it only takes 30 seconds to do the grinding, with five or six other people in line, it ends up taking about 10 minutes to grind the bit and get back to the machine. When we consider that occasionally the new edge will not be good enough, forcing us to return and regrind the bit, we might end up processing only two rods in 10 minutes.

On the other hand, we might work through a number of rods one after another. If we find that the table of the old-style drill press is too small, we might take 10 or 15 unprocessed rods and line them up on the drill press stand. On the other side, we might have 10 or 20 rods already processed that we can place in a wire basket.

The worker doing all this is imagining he is working. So, while he can only process three or four rods every 10 minutes, the worker himself concentrates on the 30 seconds it takes to actually drill the hole and compares this to the 40 seconds it takes if a rod is fed in. The truth is that, if we only need one rod every 5 minutes, we can cool the bits for 4 minutes between each rod and get away with only taking the bits to be reground once a day. You can also take the bits to be ground three at a time. So in the end, while employees may be working up a sweat and thinking that they are working skillfully and efficiently, the shop is, in fact, operating inefficiently.

4

Confirm failure with your own eyes

Even in a case like the one I have just described, it is comparatively easy to persuade people in the workplace when you actually give an idea a trial run there. When you go outside the shop, however, you no longer have any means of proof, and very often people will wind up convinced that their own ideas are the best ones.

I think perhaps the hardest to persuade are managers, higher level management people, and supervisors. Things get a little difficult, for example, when a unit leader wants to win over a supervising foreman. If the foreman is not convinced, the workers will not be allowed to give the idea a trial run. Indeed, even though the foreman may think there is some merit in what the unit leader says, neither of the two will really know who is right and who is trapped in an illusion. The result will be an argument while the workplace will remain as it was with no increase in worker productivity.

So give new ideas a chance. If opinion is divided after doing a trial run, then the two people with opposing views can spend a day running the procedure the way each thinks is right. Or you can try it the way another supervisor thinks it ought to be done. All you have to do is compare the results of these various trials until everyone is persuaded that one method is indeed better than the others.

In any case, you cannot have people clinging to their own convictions. Rather than stubbornly refusing to change their opinions, they should concentrate on identifying what is valuable in their ideas or suggestions. Focus on the positive aspects of ideas even when misconceptions are involved. If an idea does not work out right, then it is a failure

and should be recognized as such. I think it is important to get in the habit of verifying failures with one's own eyes.

In general, failure is the outcome when the only response managers have to hearing results is, "Didn't work, eh? You should have listened to your boss." The same goes for ideas that turn out to be successful — people will not be persuaded just by listening. They have to see it with their own eyes and say, "So, that's what you do! I really hadn't figured that into my calculations, but now that I've actually seen you do it, I understand what's going on."

The idea developed in this particular instance was to find some way to centralize the grinding, since spending the whole time sharpening blades or bits would keep us from making any headway. As soon as the subject of centralized grinding was brought up, one of the older, experienced people replied, "You know, we tried that during the war, but it didn't work. That's why we do things this way now."

I told him that since I had not witnessed the failure of the method during the war, I wanted to do it again so I could see the method fail with my own eyes. If I was persuaded that it would not work, I would go along with the current method.

I thought the method had failed because certain aspects of it were carried out wrong, so I said to him, "The company failed before because it was dealing with war supplies and you had people from the military here pressuring you to centralize the grinding. Of course, you're not going to get good results when you're doing something unwillingly. So, you see, showing me how the method failed doesn't really constitute failure."

Along the way, the grinding experts spared no efforts to point out things we did not know about various materials, telling us that castings had to be processed in such and such a way or how we had to handle iron. I told them that this information was irrelevant and had nothing to do with centralized grinding. To put the right angle on the blade, people doing the grinding had to know what kind of material would be cut through on which machine. All we had to do was set up standards specifying the different blade materials to be

used in each case. It would have been extremely inefficient to tell hundreds of people what they could and could not do in sharpening their bits.

In situations like this one, where experiments are failing or are about to fail, you can avoid failure by taking precautions. This approach will eventually increase productivity many times over. Indeed, you can turn out first-rate products even if the workers themselves do not possess specialized technical knowledge.

Since the end of the war, this kind of problem no longer occurs, and I don't think any production shops today go about grinding this way. Even so, I think we all labor under similar misconceptions that exert a tremendous influence over our relations with other people.

5

Illusions that lurk within conventional wisdom

What I call illusions or misconceptions can easily turn into conventional wisdom. When that happens, either debates become endless or you act so haphazardly that things do not move forward.

Conventional wisdom contains illusory elements that we want to believe are correct. So, at one time, I urged a kind of "postconventional wisdom," telling people to break away from preconceived ideas and think on their own. Also, while a rule of thumb may not actually benefit us over time, in general, the fact that it has no distinct disadvantages makes it acceptable.

To my way of thinking, having significant advantages paradoxically implies that significant disadvantages are also waiting around to have their say. Disadvantages are to be shunned; the fewer of them, the better. This notion, however, runs counter to the conventional wisdom that tells us something is all right as long as there are few disadvantages — even if the advantages are nothing spectacular.

I think we should prevent disadvantages from surfacing so that only the significant advantages remain. This is what I refer to as postconventional thinking. And illusions may intrude even here, requiring us again to break away from conventional wisdom. This requires a bit of courage.

Specifically, people at all levels in a company — top executives, middle managers, or people actually doing the work — are human beings bound together by illusions. Their work is driven by certain assumptions — they may think each other's current methods are best, or they may not, but they see no other way of doing things. What's more, nearly all companies now have labor unions composed

of people who, being human, are also subject to illusions.

As we approach a variety of tasks, therefore, we encounter areas where things do not proceed smoothly. In my view this calls for a sort of revolution in consciousness. Unless we make drastic changes in the way we think, our mental processes will be limited to a linear extension of what we have done in the past.

I really believe we will be unable to blaze new trails unless we boldly turn our thinking processes upside down, and unless everyone — from top management to workers, and even labor union people — participates in that revolution. Labor unions may be able to effect a relatively smooth revolution in attitudes, but I suspect it will be a bit more difficult for them to join a revolution in consciousness.

Consciousness-raising is enormously important. Without it, we will have to be content with 10- or 20-percent increases in productivity in terms of projections from past performance. As we discussed earlier, it is hard to give up the illusion that it is more efficient and probably cheaper to process items in batches than one at a time. Where costs are involved, "number-pushers" rush in and talk about costs in a way that creates the illusion that once a press setup is completed, it is cheaper to run 10,000 rather than 1,000 pieces. This illusion, backed up by calculations, is always acknowledged as truth.

Someone once put the following question to me: "Toyota has been able to achieve remarkably rapid press setup changes. We understand, for instance, that what used to take 2 hours or an hour and a half is now done in less than 10 minutes. But even with 10-minute setups, wouldn't it have been more efficient to process, say, 20,000 items between setups instead of 10,000?"

Now, the point is valid if you go by arithmetic calculations. In the past, we would want a press to run for at least 2 hours because each setup change took 1 hour. But by shortening setup times, wouldn't we be able to make items more cheaply by increasing the number we run through the press? Wouldn't it be more efficient that way? The question is

whether reducing lot sizes does not cut into the advantage of going to all the trouble to shorten setups to 10 minutes.

But this differs completely from the way we look at the situation. Even if I were to give a serious response to the question, the asker might not understand what I was talking about. All I can say is that his point is only valid in terms of arithmetic.

6

Arithmetic's blind spot

It seems to me that the biggest illusion for "number-pushers" lies in departing from sophisticated calculations and thinking that simple arithmetic will show how many units must be sold for costs to drop.

At Toyota, we make only as much as will sell. Although we are always saying that we should not make things that will not sell, arithmetic calculations would lead us to believe we could cut costs by making, say, 20 items instead of 10.

If you are working with strange mathematical formulas, the above conclusion may be correct in terms of those formulas. But if the formulas were correct in the first place, they would show that, in fact, costs do not decline. Maybe this is difficult to grasp. My feeling, however, is that many people fail to see the point.

Let's look at three formulas:

1. selling price − cost = profit
2. profit = selling price − cost
3. selling price = cost + profit

Perhaps the "number-pushers" fail to understand that each of these formulas means something different.

Formula #1 (selling price − cost = profit) means that, given a selling price, profit is the result of having subtracted cost from that price.

Formula #2 (profit = selling price − cost) says profit is what we have left after subtracting cost from the selling price. All we have done here is flip the terms around so that this is arithmetically equal to the first formula.

Formula #3 (selling price = cost + profit) is a bit different because it says the selling price is what you get when you put cost and profit together.

Now, these formulas may all look the same when they are written out like this. In fact, though, each one means something different, an idea that intellectuals seem to have trouble understanding.

The first formula expresses it this way: whenever you have competition or other manufacturers, the selling price is determined by a third party, that is, the customer, who sets a value on the item in question. The selling price is $250. So if the item actually cost $200 to produce, that means you make $50. (selling price − cost = profit)

With the second formula, once you have manufactured the item, you want to find a way to make at least $50 profit. Since you would make $50 if you were to sell the item at $250, you might be able to sell it for $300 if you were to put some gold threads in it. In any case, you decide arbitrarily to make $50 on every $250. (profit = selling price − cost)

As an arithmetic formula, nothing is wrong with the third formula. All you have to do is take Formula #1 and move the minus sign to the other side of the equation, where it becomes a plus sign and says that profit and cost together are the price. But the significance is entirely different. Let's say your cost is $250. If you want to generate $50 in profit, then for an appropriate return you should set the selling price at $300. You are not going to get your profit unless the selling price is $300. (selling price = cost + profit)

Now, you might say this is a good price at which to sell, but the customer might protest that only a fool would pay $300, or that he can buy it elsewhere for $250. If this happens, Formula #3 tells you that it took $250 to produce and that you would not be making any money at all selling it at $250.

What does "cost" mean in the context of these formulas? For me, costs exist to be lowered — not calculated. Formula #3 suggests that all you have to do is make calculations and come up with the correct cost. It seems to me that Formula #3 tells us — and this may sound odd — that the

government or somebody has to take care of things from that point. The way I interpret it, the formula implies that if the customer does not go along with the price, somebody else has to step in and impose a $300 selling price in order to ensure a profit of $50.

Formula #2 is the most peculiar one of all. (profit = selling price − cost) Costs are not going to get any lower by having profit on one side of the equals sign and selling price and cost on the other. What this implies is that you have to make money by increasing added value (that is, lowering the unit manufacturing cost) and producing a high-class product. It says that in order to make money you should move toward luxury goods. Maybe this is what economists mean when they say all you have to do is make things with high added value.

In Formula #1, the selling price is fixed, so the manufacturer has no choice but to lower costs. (selling price − cost = profit) Only when you have lowered costs will you make money. As a result, it may be possible to produce for $125 what used to take $200. Since the selling price is $250, you are making $125. Now, the Communist Party may denounce me for this, but this $125 profit derives from our own hard work, so it seems to me that the conceptual approach expressed by Formula #1 is the best one. When mathematics professors tell us that these three formulas are equivalent, I think we have reached a point where communication has disintegrated.

Around 1974 or 1975, an economics professor asked me the following question:

"Rather than making so many of those cheap cars and having the Americans squawking at you, why doesn't Toyota make more expensive cars? Wouldn't you have greater profits if you made 10 times fewer cars with 10 times the added value?"

My reaction was to think that this economist was being very lazy in his thinking. In suggesting that it would be more profitable to sell a few expensive items rather than a lot of inexpensive ones, he was forgetting that the selling

price is determined by a third party. We are dealing again with Formula #2. Formulas may lead you somewhere useful depending on how you approach them — and a single formula will generate a variety of ideas depending on how it is written.

Those of us involved in industrial engineering tend to see things in terms of Formula #1. We are always thinking about ways to cut costs. For us, costs are things to be lowered rather than things to be calculated. No matter what we do, the single most important issue for us is whether costs have been lowered.

Our company does everything it possibly can to reduce labor costs. It is a common misconception, however, to think that reducing labor costs means that overall costs will be lowered. At the same time, we are plagued with a lot of similar errors in the area of capital investments, especially since it is so difficult to win people over to our way of thinking.

7

Don't be afraid of lost opportunities

When we are about to put out a new car, the facilities people ask us to decide approximately how many units are going to sell. If it is 30,000 a month, then quick calculations are made. (The figuring gets done very quickly when they use computers.) They tell us how much it will pay us to invest if we're going to sell 30,000 cars. The people in charge of equipment and facilities claim that there is no way they can gear up for production unless they are told how many units will be sold.

But we don't know how well a new product will sell. "Well," they say, "a demand forecast will give you some idea." Frankly, if demand forecasts represent the extent of our knowledge, there's no point in working for the company, because we would make a lot more money going to the racetrack and betting on the horses.

Look at weather reports. They may have gotten a good deal more scientific since the Meiji era [1867-1912], but you still cannot totally rely on them. The human mind is even more impenetrable. No matter how advanced your computers may be, you still cannot expect to understand people's preferences. We simply do not know how many cars will sell. "If you don't know how many will sell," they declare, "then there's no way we can carry out facilities planning." What foolishness we run up against!

If we are lucky, these people say, customers might buy 30,000 cars a month. But if things do not work out, we may be unable to sell more than 500 cars per month regardless of how good our advertising is. They say their hands are tied by not knowing whether it will be 500 or 30,000.

Now, I may give these people a hard time, but the fact remains that it would be good to have some way to deal with this situation. We could start production on a trial basis, for example. That way we could tell whether the product performed well or not. Or we could produce small quantities at a time to see what sells and what does not.

Of course, if we come up with something really good, we might be swamped by customers. Then we would kick ourselves for losing profits we could have brought in by being prepared to produce 30,000 a month instead of 500. So I ignore the objections of the facilities planners and tell them to set up for 30,000 cars. Those among them with the misfortune of being cynical by nature may well gasp at the thought that we might not sell that many cars.

It is a peculiarity of the Japanese people that we tend to be afraid of letting opportunities slip by. After the war, from about 1955 to the mid-1970s, Japan's economy grew dramatically until the time of the oil crisis. If insufficient equipment capacity or a labor shortage blocked sales of a product that was doing well otherwise, an opportunity was lost — a loss in the same sense as lost profit or any other kind of damage.

Although the term "loss" as applied to real losses on the one hand and lost opportunities on the other has two quite different meanings, either way it ended up feeling like a substantial amount of damage. Now, of course, I see this as a type of illusion, because missing some profits does little harm, whereas actual losses can inflict real damage. The two have become totally confused.

This is why we might have gone along with demand forecasts of high sales, or why we might have looked at a product and decided that it would sell well. In the end, though, we might not have been able to get customers to buy the cars. Here, the demand forecasts would have been wrong. With automobiles, it is the sales companies that generate demand forecasts and — as much as we might want to write off their forecasts as imprecise — it would do no one any good for those companies to go under. Some-

how, we tend to be so afraid of missing an opportunity that we forget about the real loss. There is a big difference between the two in this case, but people fail to understand this. All that seems to stick in their minds is that they missed a chance to make more money.

When we say the fish that got away was the big one, we are talking about the same sort of thing. Sometimes we feel as though we have suffered a tremendous loss, but it seems to me that this, too, is a kind of misconception.

So our philosophy of insisting on lowering costs is fine when business is bad or when growth has stopped — or, more euphemistically, when growth is stable or when there is low growth. I think, however, that insisting exclusively on cutting costs forms a rather poor philosophical basis when growth has stopped — when you have a zero or "negative" growth. (Calling this "negative growth" betrays a prejudice against growth — and putting the word "growth" after "negative" makes it sound as though something is getting bigger.)

8

Limited-volume management means making things inexpensively

These days, people everywhere are talking about how they succeeded in trimming managerial fat or how a lean management style improved the state of their firms. At the same time, references to scaled-down production or higher profits from lower income occasionally show up in the business sections of newspapers and magazines.

Negative growth implies scaled-down production, but zero growth means no change at all from the previous year's figures. Low growth is merely a flattened curve, but when you have to scale down either production or volume, you will have your hands full just trying to keep costs from rising. I use the expression "limited-volume management" to refer to this phenomenon.

Make only what you can sell. If we understand this to mean that you do not make what you cannot sell, how to make limited quantities cheaply becomes a crucial issue. Suppose you can only sell 10,000 cars. It is rather odd then to talk about how much costs would drop if you were to make 15,000 cars. Obviously, it is important to see whether the company will make money or lose it. It is only natural for this to result in the illusion that 15,000 cars would be cheaper to manufacture than 10,000.

Now, although I believe under certain circumstances it actually would be cheaper to make 15,000 cars, suppose you did make 15,000 and only sold 10,000. Would you really be making money by having the remaining 5,000 cars piled up somewhere gathering dust? If you are only going to be able to sell 10,000 cars, then make those 10,000 as inexpensively as possible. Yes, it may cost you more than it would for

15,000 cars. Nevertheless, a philosophy of making things as inexpensively as possible calls for "limited-volume" management and a "limited-volume" production system.

With stable growth or low growth, increases in output are carefully managed. An increase under these circumstances may mean an output only of 11,000 cars. But since even this is a limited volume, it is still important to think of ways to produce those 11,000 cars inexpensively.

Trimming away fat involves the removal of excess weight, while "limited volume" refers to production output. One expression implies weight and the other, quantity. "Lean" management does not have anything to do with lowered output. It is like a boxer who falls into a certain class defined by weight limitations. If he skips a few training sessions and puts on weight, he can no longer compete in his class. Since that would be a disadvantage, he diets to slim down and maintain his weight. If his diet is not suitable, he will run out of energy and lose the fight. Obviously, this sort of slimming down is undesirable.

The same thing can be said for a company. It is all very well for a company to go on a diet and work off excess fat, but I think it's a dangerous idea to trim down management so much that you cut into the essential meat of the company.

9

Less inventory and more work-in-process

Perhaps thinking I would praise them for it, people at one company told me they had reduced inventory and trimmed off excess fat from their operations. Further inquiry revealed they had decreased their materials inventory. Would cutting back so drastically on materials perhaps lead to production problems later on? No way, they assured me. I had them then show me the plant and found nothing lean about the operation at all — because the reduced inventory had turned into increased work-in-process.

The point here is that raw materials and other materials should not be inventoried in any form. When your materials warehouse is located near your manufacturing division, it is generally disastrous when, with the certainty of ownership showing on your face, you wearily get something out of the warehouse only to discover that, while in storage, it has been bent out of shape.

You might be holding considerable inventories of raw and other materials and it will have no connection with how well managed your firm is. If you know unit prices will rise, then you will want to buy materials while they are still inexpensive. This is understandable from a business point of view, but, once purchased, they are yours, and it is up to the plant to turn them into something. Since it would do no good to set them aside, you process them in some bizarre way so they become work-in-process. This, too, is extremely undesirable.

The "restricted volume" we refer to at Toyota means not making what you don't need. If you can't sell it, don't make it. The same thing goes when using machines. For example,

suppose we have three processes. Process #1 takes 1 minute, Process #2 takes 2 minutes, and Process #3 takes 1 minute. Thus you have different processes that take different amounts of time. Since Process #2 takes twice as long as Process #1, Process #2 is still working on its first item when the worker at Process #1 finishes. Since the person at Process #1 is finished, he begins work on the next item, and this results in having two pieces end up as work-in-process. In this way, work-in-process will continue to increase steadily.

You can't sell work-in-process. Yet, as we make it, we think we are somehow being more efficient even though we are not supposed to make anything we can't sell. On the other hand, if Process #1 can handle 60 pieces per hour, we argue, it would be a waste to stop at 30 per hour just because Process #2 cannot turn out any more. This gives rise to the illusion that it would be better as well as less costly to do your utmost to make 60. That way, you think you have made a lot of items quickly.

And what on earth does the company do with a lot of efficiently-made things that it cannot sell? The company has to pay salaries to its hard-working people. It has to buy twice as many materials. And then there is the cost of electricity. While producing half as much would have brought the electric bill down a little, you are doubling production and having to pay large sums to the power company. In the final analysis, despite your original intention to reduce costs, when you produce goods you cannot sell, the only effect on the company is to impoverish it.

What happens is that one process cannot sell its output to the next process. We see each process as the customer of the previous process — Process #2 is the customer for Process #1 — and we cannot sell if the customer will not buy. The same goes for the relationship between Process #2 and Process #3. If the person at Process #3 cannot use an item, then no matter how much of a bottleneck the 2-minute Process #2 may be, it makes no sense to make a trial run while the guy next to you is off to the rest room.

To exaggerate a bit, the moment profit and loss concerns enter the question, everyone falls prey to illusions about

something essentially very simple. You can make unsaleable things as inexpensively as you want, and some people will only respond by saying, "the cheaper the better." It is not surprising that large numbers of such people can eventually drive a company to the poorhouse.

If you slack off and make nothing, then you can get by without having your machines wear down. You might even be able to use rickety old machines for 20 years if you shut each one down for half a day. Since 10-years' depreciation is allowed for each of them, after 10 years such machines can be used to maximum advantage.

I have already pointed out that you can devote a lot of effort to drilling holes with a drill press in 30 seconds and end up spending 7 hours doing a job that could be done in less than an hour. If you then ask for a raise because you have worked so hard, the product will end up being an absurdly expensive product. You will only have raised your costs, won't you? Is this really the way to bring down costs? When the accountants say that costs have been held down, it seems to me that, rather than swallowing their story whole, you have to look into whether real costs for the company have declined or not.

In companies where a single piece of equipment may perform a number of different tasks, many items can be produced at the same time. First you make Part A up to a certain point, then you set up Part B and make it efficiently, then you start on Part C. In terms of accounting, the figures will show that it is cheaper for a press — this is not the press we discussed earlier — to be used to the fullest, to make 10,000 items rather than 1,000 items. If you do, however, you run out of space to store the items unless you build a warehouse. So you build a warehouse. Because you have a warehouse now, you continue making things according to calculations that show it is cheap to produce unsaleable products. Before long, numbers and quantities grow so much that you have to build racks in the warehouse. Then you have a problem with waiting time, but you put in a computer so that a push of a button allows you to add or re-

move items. But why put so much money into something you made a point of wanting to produce inexpensively?

You went to a lot of trouble to make a product for ¥100. Yet how much more expensive will it have gotten by the time everything else is added on and you turn it over to the customer? You can calculate manufacturing costs as much as you want, but things are not going to add up.

Look at transportation costs. A common way to calculate them goes like this: if manufacturing division people do the transporting, then transportation costs are included in the manufacturing costs. Once specialized transportation workers take over, however, transportation is included in general and administration expenses and costs drop. This is nonsense — a particularly flagrant example of what happens when you go along with conventional bookkeepers' wisdom.

The fact remains, however, that many people simply go by the numbers and fail to understand clearly whether costs are high or low. They figure that since transportation costs are part of general and administration expenses, costs can be lowered by making general and administration expenses more rational. The manufacturing division does not worry about such matters; they just want their own costs lowered.

What happens is that from an accounting point of view costs will rise and fall. When they do, I hear everyone complain that the situation is intolerable, yet they continue to come up with silly reasons to explain why they can't rationalize operations in indirectly related departments. This way of thinking about things is widespread, but in my opinion, it's a big mistake to be deceived into thinking costs have really dropped.

10

The misconception that mass production is cheaper

Here is another piece of conventional wisdom based on a widespread misconception: it is generally thought that mass-producing something makes it cheaper. Thanks to this notion — although it seems odd to be thanking it for anything — the idea that it is right and proper for items produced in small quantities to be expensive has become another bit of conventional wisdom. But does mass production really make things cheaper? I have had occasion to see quite a few things manufactured in my time, and I have come across only a very few instances where increasing production quantities lowered costs. Usually it raises costs.

What I mean by this is that the productive capacity of a given workplace is generally fixed. The quantities at which various machines will produce items less expensively are likewise fixed. It might be cheapest, for example, for a certain press to stamp 1,000 pieces per hour. The question is whether it would really be less expensive to have that same press stamp 1,200 pieces per hour.

Obviously we cannot just go out and buy another machine. So we are talking about running the machine 20 percent overtime. Depending on the company, overtime means you must pay workers an extra 30 or 40 percent. So if you make 12,000 items during overtime, your real costs increase by the amount of the bonus you have to pay workers.

Suppose your machine can turn out 10,000 units. If you only have orders for 8,000, then you will have the machine make 8,000 and, of course, it will cost more than if it were making 10,000. You might be tempted to say mass production would be cheaper but, in this case, unless you bring that

8,000 up to 10,000, costs will rise when you produce the maximum amount the next time you are told to exceed your machine's capacity. Thus, up to the limit of a particular shop's or plant's capacity, it is true that per-unit cost will fall as you increase output. Once you pass that limit, however, costs will rise, perhaps 30 percent.

Let's say you buy a new machine because you do not want complaints from the unions. Now that you have two machines, however, your work rates will be unsatisfactory and your costs will remain high until you reach 20,000 units. The fact is that, while in some cases greater output really will lower costs, there are other instances in which, up to a certain point, increased output will raise costs.

Was it a good idea to have bought that new machine back when economic growth was at its peak and income was doubling every three years? As long as things are going well, you may, indeed, remember your investment as a wise one. When times are hard, though, you will have a hard time forgetting the mistake you made. The upshot of all this is that mass-producing something does not necessarily make it cheaper.

There is one more area in which lower costs can be achieved with small quantities. Take the example of a setup change on a press. Suppose a retooling setup that used to last one hour now only takes 10 minutes. When dealing with a small number of items, you can process them all in the time you have saved. If it now only takes 10 minutes to do a setup that used to require one hour, you could retool for the low-volume Part A in 10 minutes and process scores of pieces in 10 minutes. In another 10 minutes you could retool for Part B and then do 10 minutes of processing. When you are 10 minutes away from the one-hour mark, you could get going with the large-lot Part C. This means that, in the time you save, you can process 50 or so of each kind of small-lot item.

It seems as though we have gotten something for free in this example. The accountants may not accept the idea of something for nothing, but the fact is that cooperation has made it possible to do in 10 minutes what used to take an

hour. How do we link that savings to lowered costs? With those 50 minutes, rather than figuring that it would be cheaper to process Part A in greater quantities, we can complete, say, 50 additional units per month. When we move from Part B to Part C and find we have time to process other low-volume Parts D, E, and F, we have ended up with a situation in which it is extremely inexpensive to produce goods in small quantities.

As I said at the outset, the common notion that mass production leads to lower costs implies that low-volume goods will inevitably be expensive and that they will still sell. This means somebody is going to make a lot of money. In fact, money will come rolling in as long as conventional wisdom says that high diversity and low volume are more expensive. I am sure there is more room for cost reduction as well.

There are many illusions at work in the world, and as long as they form the basis of conventional wisdom, there will be any number of ways to increase profits. It all boils down to how we use our heads, leaving us innumerable ways to lower overall costs.

Low-volume production ends up running into really big money when you have people solemnly citing individual costs and going on about what is profitable and what is not. All too often somebody tells you that you have to give up on your most profitable car because numbers show you are in the red. So you abandon the model that has really been making you the most money and break your back trying to sell lots of unprofitable cars as though they were making you rich.

This situation is not limited to automobiles. It shows up frequently in other industries as well.

11

Wasted motion is not work

Being pretty good at the Japanese language, I would like to give you my interpretation of several important words. In writings about the development of Japanese industry, two written characters often show up, [動] (moves) and [働] (works). As those of you who know Japanese are aware, these two characters differ in the presence or absence of the element [亻] (person). Both characters, however, can be read the same way, *dō*.

In other languages, such as English, this is a little difficult to see, because "to work" and "to move" are pronounced completely differently.

The year before last I went to China and ran into some difficulty. The Chinese left things scattered around the workplace, whereas in Japan we carry out "Four S" campaigns. The four "S's" stand for:

- *Seiri* — consolidation
- *Seiton* — orderliness
- *Seisō* — sweeping up
- *Seiketsu* — cleanliness

We award prizes for tidiness and do various things to plant the idea of orderliness in people's minds. I explained to my Chinese hosts that we use the expression "Four S" to refer to such activities. "Why 'Four S'?" they kept asking me. Apparently, the first two words in the list, *seiri* and *seiton*, are pronounced with an initial "s" in Chinese. The other two, however, *seisō* and *seiketsu*, are written with a character that in Chinese is pronounced "ching." Actually, this reminded me that I had

seen this character in mah-jongg before, where even in Japanese we pronounce it "chin." When we turn our attention to work, somehow, we get too far away from the mah-jongg table.

When my Chinese hosts read the characters with which the words are usually written, they cannot read them as beginning with "s." So I explained that writing out the romanized words *seiri, seiton, seisō,* and *seiketsu* shows that each of them begins with an "s." At any rate, I told them just to remember them all as beginning with "s." In much the same way, [動] (*dō*) and [働] (*dō*) in Japanese writing are distinguished by the presence or absence of a graphic element meaning "person" [亻]. With this element, the symbol means "to work." Without it, it means simply "to move."

However, because the pronunciations are the same, we Japanese tend to have the same image of the two characters. This raises some problems. For example, I'm not trying to make a pun, but the town of Toyota, where our plant is located, used to be called "Koromo." There, in the local dialect, [動] and [働] are used in exactly the same expressions. In Koromo, to say a wife is a "good mover" means she is a good worker. It's the same thing.

Anyway, we built our plant there and found that, sure enough, for Toyota workers, moving was the same as working. They assumed anything you put a lot of effort into was work, and we had a difficult time convincing them otherwise. Just because somebody is moving does not mean he is working. We had to get people to realize that there is a world of difference between simple animal movement and the same movement guided by human intelligence.

A bear in a zoo will move back and forth in her cage. In terms of the bear herself, this is probably just meaningless animal movement. Yet because of this movement, children will gather in front of the cage and people will pay to get into the zoo. The bear's *work* causes the movement of bodies in front of the cage. The bear's *movement*, which would take place whether or not there was anyone watching, is simply animal movement.

The distinction I want you to see here is that this same movement can be either work or just meaningless movement. Suppose there is a certain limit to the bear's strength. If no visitors are present, you can send her to the back of the cage and keep her still. When a group of children gathers, you have her walk around the front again and, indeed, the bear has done good work for you when the delighted children tell you they will return next Sunday.

It's the same with elephants. When a crowd gathers on Sunday, you bring out the elephants and have them do tricks. Here again, human intelligence is guiding the elephants to do work. With monkeys, you do not have to do anything for them to move around in response to visitors. Monkeys will work all by themselves. In that case, you might think, we should write the character for work as "work" accompanied by an element signifying "monkey." But that would be misleading. The right way to write the character for "work" is to combine "person" and "movement."

Thus, the Japanese writing system is very helpful on this point. Indeed, I think Japanese characters make a significant contribution to industry in terms of generating illusions or letting us see illusions for what they are. Someone who once heard me make this comment suggested that the elements for "movement" and "liquid" could be combined into a new character. "And what would the character mean?" I asked. "To bar-hop," came the answer. "To move from one place to another and drink." Personally, I don't see it, but I suppose the person who made up the character is free to imagine what a combination of "liquid" and "movement" might mean.

I often tell supervisors that they, too, should train themselves to distinguish between movement and work — in other words, to cultivate an ability to find waste. The idea is to question the connection between movement and the task at hand.

Suppose a certain process involves changing the shape of objects by machining them. And suppose somebody there

is working as hard as he or she can to pile the objects on a chute and manages to stack them five layers high without having them fall down. In a situation like that, an adult is behaving like a kindergartener and collecting a salary for it — a situation from which the company does not profit in the least. Here, the most important job of the supervisor is to be able to say that things are unacceptable the way they are.

We visit numerous companies. When we go, plant managers or executives usually give us a tour. Now, I do not know whether this is standard Japanese or the Toyota or Mikawa dialect, but there are two expressions we frequently hear in this setting: *dekichatta* (we have succeeded) and *dekiru* (we can do it). Unlike the English word "can," however, these expressions mean something is accomplished. If you use the past tense and tell me that you *dekita* (managed to do it) or that you have *dekichatta* (have succeeded), we ask: do you mean you were successful because everybody worked furiously to get the job done, or do you mean you had someone else do the work?

Typically, we do not get a satisfactory response to this question. Why? Because ascribing success to everyone else's hard work might imply the absence of managerial ability, while saying you had other people do the job might suggest that you are making people work only to impoverish the company. So, either no answer is forthcoming or any answer we do get is meaningless. What this boils down to is that a manager's competence will be called into question unless he can restrain himself from declaring that he is *dekichatta*.

Still, one hears a lot of talk about *dekichatta*, or "success." "We succeeded because everybody worked so hard," people will say. But what is the most crucial task of production management? Isn't it to hold down excessive "success," to curb overproduction? Yet people boast about having "succeeded." If criticized, they are content to point fingers at the people working under them. This attitude has nothing to do with production management.

12

Agricultural people have a penchant for storage

Descendants of an agricultural race, the Japanese people harbor a certain nostalgia for farming. Agricultural people settle in one place and stake out fields and paddies nearby. Fluctuations in natural phenomena mean that harvests are sometimes good and sometimes bad. In Japan's case, frequent typhoons are a special threat, and a typhoon or a drought can lead to a drastic drop in output. This is why the idea of storing the fruits of good harvests lies at the core of the Japanese mentality. With all the advances of modern science, even those of us in industries unrelated to agriculture will put something aside for whenever we encounter a little rain or a stretch of foul weather.

We have the firmly fixed belief that people should produce as much as they can when they have the chance. When machinery is running well, we think it best for everyone to work together to produce as much as possible, because things will be a lot harder when equipment breaks down or when absenteeism increases. Indeed, although I may rail against it, this feeling of not wanting to run out of things characterizes a little of the farmer's mentality still lingering in the depths of my own thinking.

A race of hunters is different. When a hunter runs out of food and gets hungry, he kills a pheasant or whatever and eats it. Agricultural people may eat the same animals, but if one of them kills a pig, for instance, although they may eat it on the spot, they will wonder about how to store it. Thus, storage becomes highly developed. This is why agricultural people are especially good at storage technologies and inventory management.

As a result, rather than getting tangled up talking about production management, we want more than anything to know how we should go about managing inventories; after all, we have already managed to find ways to produce things. We just can't rid ourselves of the gut feeling that inventory management is more interesting than production management. Books on production management hardly sell at all, while books on inventory management sell like hotcakes.

You point out that Toyota keeps no inventory and has no warehouses, but it will be thought of as a special case. There is still something about human beings that makes them want to be able to send things to customers at any time. So they build warehouses. And the warehouses they build get bigger and bigger.

Now, in agricultural terms, since famine could strike at any time, you put rice aside when you can and store it so it's not eaten by insects. In the end, the supposed emergency reserves — and by that I mean stores to be brought out and eaten only in times such as famine, and not, as in the old days, war — are preserved for years and increase over time.

In the old agricultural days, and even when I was a child, we used to hear the expression "going broke with a good harvest" (*hōsaku binbō*). The bigger the harvest, the cheaper rice becomes. Or you could say the same thing about fishing. You might catch so many fish that you throw some away because the boss would be angry if you returned with all you caught. In short, then, a good harvest or a good catch means prices will fall. A bad harvest or catch leads to scarcity and higher prices, and these forces combine to determine market values.

Once market prices came into being, over the course of a number of years we saw the gradual emergence of the idea of controls to keep prices the same whether production levels were high or low. That means we have to pay high prices for rice regardless of how much surplus there is. In terms of costs, on the other hand, the price we ought to be buying the rice at is based on how much it costs to produce. And these costs are calculated quite strictly.

The selling price is the sum of costs plus profit, and since nowadays we would be dealing with power cultivators, this would mean some hundreds of thousands of yen as a basic unit. By figuring how many kilograms each machine produced, we would arrive at the per-kilogram depreciation cost of the cultivator. A good harvest also requires fertilizer that costs so much per acre. This will give us kilograms per acre. Then we calculate how much we need for a farm worker's daily wages — that is, his labor — compared to those of a factory worker.

As I said at the outset, if we make ourselves prisoners of costs by assuming that costs exist to be calculated, then farmers are going to lose interest in farming unless they make a certain profit. The price of rice will eventually soar as a result. As things stand, we no longer have official market prices for rice, and, in the years since the Meiji era, the influence such official quotations once had has shifted to other industries.

13

Cut production and raise productivity at the same time

Modern Japan had an enormous rice surplus, so much so that producing so much rice was becoming a problem. A cut in production was deemed necessary, so the nation cut back on the acreage devoted to rice cultivation.

Some rice paddies were simply destroyed because, once eliminated, they could not be used for growing rice. People let wild reeds grow where rice had once been. Farmers received payment according to how much land they had taken out of production. They then took that money and traveled overseas. In London, Paris, and other cities around the world, tourists from Japanese agricultural cooperatives made themselves welcome guests.

But there was still too much rice being produced. As a result, acreage was cut back even more, and it was agreed that farmers would not grow rice on, say, one-tenth of their land. Cutting production by 10 percent was all right with the farmers because they simply increased by 10 percent the output on their remaining lands.

Thus, even though acreage had been cut, overall production did not change one bit. One might conclude from this that the acreage reduction method was not carried far enough. But it seems to me that what really happened was that calculations ignored the role of productivity. If the government wanted to make a 10-percent reduction, it should have told each farming household to produce 10 percent less rice than it had the previous year and that it was up to them how to do it. They could use more land if they wanted, but they would be told that there was simply too much rice being produced and they would have to cut back.

Instead, however, the government told them to stop planting seedlings in certain rice paddies. It should have come as no surprise that yields could be raised 10 percent by taking the leftover seedlings and concentrating them in the remaining useable land. This one piece of evidence showed that government officials left the question of productivity entirely out of the picture. Whether in the Ministry of Agriculture, Forestry, and Fisheries or the Ministry of International Trade and Industry, they all shared the same fixation.

When an industry becomes a victim of structural recession, its excess machinery must be discarded. After all, its capacity is too great with all the equipment it has. So, you get the company to throw away some machines. Then, however, it wants to install more efficient equipment, so you have gotten rid of 10 percent of the inefficient machines only to bring in half that number of new machines that are twice as efficient. You still end up producing too much.

Naturally, the top people in the industry are just like the rest of us — descendants of the same agricultural people. One expects them to be sympathetic. Even so, whining will get us nowhere with them. It is our job to give more thought to productivity. I feel it is important to do away with the idea that productivity cannot be improved or that costs will fall if only we produce more items.

Productivity and productive output are linked in an unseverable cause-and-effect relationship. A rise in output often means an increase in productivity. I think we would agree that it is extraordinarily difficult to raise productivity in the face of declining output. Let's say output increases by 10 percent. If you have the same people producing the products as before, then productivity has gone up 10 percent. Or, let's say sales grow by 20 percent. Even if you have increased the number of your workers by 10 percent, you are still dealing with a 20-percent rise in sales. So productivity can be said to have increased by 10 percent. You do not have to be Japanese to do this; there are people all over the world who can do it.

But is there any way to raise production when you have zero growth, that is, when output does not increase? Japan's full employment system does not give you the alternative of firing people. If output falls by 10 percent, then productivity falls by 10 percent as well. It is almost inevitable.

Now, it may be that everybody surrenders to what is almost inevitable. Suppose, however, that you look for something that is not "inevitable," that is, for some method to increase productivity even when output is falling. Any company with people smart enough to find such methods will be well positioned to ride out a recession.

I don't know whether this is a good example, but let's say output has risen by 10 percent. What would happen if you were to cut machine revolutions by 10 percent? Machine revolutions, or motor rpms, affect electrical consumption in a 1-2 ratio. Thus, in general, cutting machine revolutions by 10 percent is said to result in a 20-percent energy savings.

Conversely, increasing revolutions by 10 percent would eat up an additional 20 percent of energy. Even though this is common knowledge, everyone still maintains machine speeds when production is reduced. If output is to be cut by 10 percent, then you slow down machine revolutions by 10 percent to make the numbers come out right. Naturally, a 10-percent cut in revolutions will lower electric power use by twice that amount. Even with the same number of workers as before, efforts of this sort will at least keep costs from rising.

Here is another example: you have the people with you no matter what. In Japan you cannot just lay off people as they do in America. The situation varies according to the scale of the plant, but even in Japan we use a considerable number of labor-saving machines and other labor-saving equipment. Actually, these products are manufactured by firms affiliated with Toyota and we would like to see a lot of them sold. At any rate, today even small firms have one or two forklifts or similarly handy machines. These devices are advertised as enabling a single worker — even a slight person — to carry heavy items for some distance and stack them.

However, if these are battery-powered devices, the batteries have to be recharged. Gasoline-powered versions consume gasoline. What's more, the tires eventually wear out from moving back and forth. If output is to be cut, then, why not stop using such devices? The surplus manpower left from production cuts can be employed to transport items. At the very least, this will lower costs by the amount of forklift maintenance expenditures. This may not be as effective as laying off workers would be in terms of saving labor costs, but that does not make it a good idea to resign ourselves to inaction.

One of these days there may be a slowdown in car sales. When I first saw this happen around 1974, I had the idea of reducing the size of units requiring transport. The automobile business was in a bit of a slump in 1974, but there was strong growth again starting in 1975. At the time there seemed to be no particular problem, but if the same thing were to happen in today's environment, there might have to be production cuts.

Because a similar situation is bound to occur again some time, since 1974 we have been making irregular, but steady progress in minimizing the size of transport units. With a forklift, you may be able to move things simply on large pallets, but you cannot transport that way in a recession. We are gradually switching over to boxes of a size that a single worker can carry or to items small enough to be transported by a handtruck. Another approach is to load pallets with stacks of boxes that a single worker can carry — not with loose items. When the next recession comes around, we will be able to get rid of the pallets and forklifts and transport the boxes by hand.

Some devices currently in use can be clamped pneumatically just by turning a valve. This use of air, however, requires that we run a compressor. If we shut off the compressor, excess labor capacity can be put to use clamping the same items manually. Such efforts do their small part in preventing costs from rising. They allow us to keep costs down even when production is cut.

14

Rationalize your operation when business is booming

People involved in manufacturing should think constantly about the kind of efforts we have been discussing. Some may feel that when production drops all you have to do is switch over to expensive products, to items with more added value. But the world is not as simple as that. While an ideal strategy if it works, if it doesn't work, you cannot just stand by and watch your company go bankrupt. The time to intervene is *now*.

If you are not preparing yourself all the time, you may end up losing everything when the bad times finally roll around. You may need money because you have to remodel pallets or use smaller boxes or build handcarts. The Japanese have a saying that expresses the sort of flexibility required: *flour is more valuable than cake*. The idea is to behave all the time the way you would if business were bad. That is what it really means to make an operation more rational.

Rationalization ought to be carried out when business is booming or when you are making money. [The term "rationalization" is often used in Japan to indicate activities undertaken to upgrade technology, improve quality, and reduce cost.] If you don't rationalize until you have run out of money, you will be left with no alternative but to fire people. It may make managing easier if you wait until things get really rough before cutting away the fat, but by then there will be no fat left to cut. Trimming down by cutting into needed meat hardly constitutes the true meaning of successful "lean" management. Indeed, I think the crucially important point in rationalization is to make operations more rational when business is good and while the company is doing well.

Arithmetic formulas and real results may sometimes match up when business is good, and as long as it remains good, one tends not to be inclined to push too much. This may not turn out to be a very profitable attitude, however. When business is booming, it would be a supremely incompetent manager who turns off forklifts in favor of manual transport, and who makes up for a shortage of workers by bringing in extra people and telling them to produce more.

Laying off people is impossible in a country like Japan where full employment is the rule. These days, moreover, something has to be done with middle-aged and older workers. At the same time, current law stipulates that one must use a certain number of handicapped people. Thus, government is steadily saddling business with various items that raise costs. You cannot cut back by firing people because you have to maintain employment levels.

In a business like the Japan National Railway, which can tolerate losing infinite amounts of money, it does not matter how workers are used. However, you and I in our private companies are different. We have to make a profit. I don't want to belabor the point, but the way to make profits is to strive to improve performance by lowering costs. This does not mean making a profit by driving workers like slaves or by underpaying them.

We need to lower costs in a truly rational, scientific way by totally eliminating waste. This, it seems to me, constitutes the single most important task facing the industrial engineer. One might remember that "poverty breeds dullness," because being poor engenders no wisdom. Indeed, poverty leads one to concentrate on trivialities. This is why I believe wisdom is to be gained when business is good.

Apparently, today some industries are laughing all the way to the bank over market conditions — but they would do better not to carry their rejoicing too far. On the contrary, now is the time they ought to be rationalizing their operations as much as possible in anticipation of the slump that may be just around the corner.

15

Just-in-time

"Autonomation" and "just-in-time" are terms used in describing the Toyota production system. I had not thought much about it until now, but recently it was called to my attention that "just-in-time" is a phrase coined in Japan, probably by Toyoda Kiichirō, Toyota's first president. Lately I have come to think of "just-in-time" as a Japanese expression put together from English words.

The expression "just-in-time" may not exist according to those — like the Americans or the British — whose native tongue is English. It may be incorrect. One person has explained to me that the proper English for what we want to say is "exactly on time." Now, "just-in-time" may not be English, but I think it is a very appropriate expression. Translated according to Japanese perceptions, "just-in-time" is used in the sense of "just at the last moment."

"...in time" may be peculiar English. But we are referring to *timing* and not to time. Whether one's timing is good or bad will determine whether it "makes it" at the last moment or not. Since the issue is timing, we might have used the expression "in timing." Now, this may or may not mean anything in English, but seems to match our intention. We use the word "just" to convey the sense of being on time without being too early or too late.

The word "just" as used in the English phrase "just a moment" does not mean "exactly" or "precisely." In "just-in-time," the word "just" suggests an event that is neither too late nor too early. If I need something this afternoon, I should have it brought at least by noon. If it showed up yes-

terday, it is too early; it is not here "just" in time. A day's difference matters. At any rate, I think the expression "just-in-time" works quite well in Japanese.

The English expression "exactly on time" means to match a certain point in time, as a sign at an airport saying "on time" in reference to flights that depart on schedule. In Japan we use "just" in the same sense as in "just a moment," but foreigners tell us we should say, not "just," but "exactly" or "precisely" on time. They say this because they think Toyota's "just-in-time" system means that something scheduled to be delivered at 11 a.m. shows up at precisely 11 a.m.

People who know English well, even among the Japanese, think "just-in-time" is not English and conclude that deliveries at Toyota are very strict. Yet we are not strict about time at all. The same standards apply to both in-house and outside products. We want to have them delivered by 11 a.m. today so they can be available by 1 p.m. If they show up at 9 a.m., they are too early; they are not "just" in time.

People get angry if we say "just a moment" and then make them wait three or five hours. By having the items delivered by 11 a.m., we still have one or two hours' worth of parts at the line before we run out. The idea is that things will proceed most smoothly as long as there are parts at the line during that hour or two-hour interval.

"Just-in-time" means having things ready when needed in the sense that items should not arrive too early. Some people think of Toyota's "just-in-time" system as being very rigid and assume purchasing will get angry if a delivery is 5 or 10 minutes late. Such negative publicity may be a bit awkward to deal with, but I, for one, remain impressed by the term "just-in-time." Whether it is Japanese or English, I think the expression was well chosen.

I am told that in the early years following Japan's opening to the West, there was a kind of pidgin speech called the Yokohama dialect, which consisted of a mixture of English and Japanese. It seems to me that the expression "just-in-

time" represents quite a successful use of English in Japanese. It really does not matter if English speakers prefer to use "on time" or "in time." At any rate, I am more impressed than ever by Toyoda Kiichirō's genius when I consider how easily the phrase "just-in-time" seems to roll off the Japanese tongue.

16

Toyoda Sakichi's theory of autonomation

When I graduated from the mechanical engineering department of Nagoya Industrial High School in 1932, the economy was still in a slump in the wake of the Manchurian Incident and there were few available jobs. In the end, I happened to be picked up by Toyoda Spinning and Weaving Company, a thread manufacturer. The cotton thread business, perhaps because it was export-oriented, was the leading industry of the time and showed tremendous vigor.

Toyoda Spinning and Weaving was a very exacting company and all new employees were made to work for daily wages as ordinary workers for three years. After my three years, I was made a manager with responsibility for part of the spinning operations, a position just below that of a maintenance or operations section manager.

It happened that next door to Toyoda Spinning and Weaving was a company called Toyoda Automatic Loom, a firm that manufactured a power loom of its own invention. We used their looms to weave cloth. Although I had entered Toyoda Spinning and Weaving in the spinning division and was not involved in the weaving side of things, I subsequently came to appreciate what a magnificent invention the power loom was. At first, I did not realize what a terrific machine it was because I had just entered the firm in a minor position. It turned out, however, that people were using that wonderful invention in the wrong way. The loom had some truly first-rate features which were not being utilized wisely.

The same can be said of Ford's conveyor device, the automatically moving assembly line. We recognize now what

an incredibly productive machine it was, because it raised productivity by applying mechanical power to work that, until its invention, had been carried by muscle power alone. The crucial feature of the loom was the presence of a mechanism that shut down the machine whenever the thread broke or ran out. Toyoda Sakichi, the loom's inventor and Toyoda Kiichirō's father, referred to this feature as "autonomation," or "automation with a human touch."

Earlier power looms had drawn mechanical power from large centrally-located motors through a system of pulleys and belts. After the subsequent development of smaller and smaller three- and five-horsepower motors, individual looms came to be provided with their own motors. At the time, these were referred to as "independent motors." I suspect that this development led almost immediately to the appearance of looms that were automated, but not "autonomated." Each loom had its own power source and would weave cloth as long as the motor kept running.

The focus of Toyoda Sakichi's invention was the crucial question of how to stop the machine when the thread broke, because broken threads led to the production of defective goods. The machine would go on weaving in spite of the broken thread and the result would be a defective product. Nowadays, we interpret "autonomation" as an effort to avoid defective products, but people at the time were more interested in raising productivity and pushing workers to produce even more. Attention was focused on getting quickly to stopped machines and reconnecting threads, so the equipment could start producing again.

Machines that had stopped would simply remain shut down rather than continue to produce inferior goods. So, the next move should have been to find some way to make thread that would not break. Instead, since broken threads halted production, attention was directed at having women run to reconnect threads and restart the machines.

Perhaps it was uncharitable of me, but I concluded that, by choosing to enhance the performance of labor to improve output, Toyoda Sakichi's "autonomation" concept

had been misused for the purpose of making more money. Autonomated parts were also used here and there in spinning machinery. But in such cases, also, the fact that such parts halted production led to an emphasis on getting workers to increase output.

During World War II, Toyoda Spinning and Weaving was absorbed by the Toyota Motor Corporation to become the company's fibers division. At the conclusion of the war, the division again became a separate company with the old name of Toyoda Spinning and Weaving. In the meantime, I had been working not with cars, but with aircraft parts, drawing brass tubing for oil-cooling devices used in airplanes.

After about a year of such work, however, I transferred to what is now the main plant of Toyota Motors, about six months before the war ended. I was put in charge of the final assembly section.

In the automobile business, too, there was a strong tendency to think of production as depending on worker effort. My feeling, however, was that we had to come up with ways to automate so that we could produce more and still use the same labor force.

17

The goal: a tenfold increase in productivity

Around 1937, when I was still at Toyoda Spinning and Weaving, a plant manager of another company returned from a tour of German and American plants. I happened to be sitting next to this manager when he declared that productivity in Germany was three times what it was in Japan.

When the Japanese suggested a certain task would take 1,000 people to perform, the Germans said they did it with 300 people. If you asked about how much a given number of workers could do, it would be three times what it would be here. The manager concluded from this that they were three times more productive than we were.

After going to Germany, this manager visited similar companies in the United States, and he made the further claim that German and American productivity were in a ratio of 1-to-3. This is how I was told Japanese productivity was one-ninth of U.S. productivity.

Now, at the time, there were probably no transfer machines around. In Japan, furthermore, the fact that we did not have domestically manufactured machinery and were working with machines from America or Europe meant that there was little difference in terms of equipment. And yet, in spite of that, there was a 1-to-9 disparity in productivity! I could not imagine how this was possible.

Later in the postwar period, it may have been true that U.S. productivity was high because of superior American machinery, but immediately after the war, I suspect that Japan and the United States were both using equipment that was more or less the same. When the Allied army came ashore in Japan, somebody from General Headquarters

(GHQ) made a pronouncement to the effect that U.S. productivity was eight times higher than in Japan.

I had heard in 1937 and 1938 that American productivity was nine times higher than in Japan. It seemed to me that if the ratio had dropped to 8-to-1 during the war, Japan had made a little progress. Be that as it may, the disparity was still unimaginably large.

The GHQ ratio of 8-to-1 was an average, so productivity in a key American industry like automobile manufacturing was probably at least 10 times higher than in Japan. How could the Japanese auto industry survive? How could we increase productivity tenfold? I gave a lot of thought to the problem and one thing was clear. There was no way the Japanese automobile industry could survive with the methods it had been using. We could not catch up unless we increased our productivity at least 10 times. How to achieve that tenfold increase was a problem that occupied me for some years.

Such high productivity was not to be found everywhere. Ford and General Motors would have high rates, but a large productivity increase probably was not the sort of thing we could copy from their operations. Somehow or other, we had to come up with an entirely new approach. This was the soil in which the Ohno production system first took root.

At the time, Toyota's final assembly plant used conveyors in assembly-line operations. When I was working in assembly, I heard from old-timers in the assembly area that Toyoda Kiichirō, the company president, had told them that the most efficient assembly method was to have each part arrive at the line "just-in-time."

Up until then, parts had been delivered whenever they were finished. As soon as an engine was completed, for example, it would be shunted over to the assembly plant. On the other hand, steering wheels or something else would be missing, so what were referred to as "intermediate warehouses" would fill up with parts and the actual assembly of cars was impeded. Even if most parts were finished and ready, a car still was not a car without a steering wheel or an engine. Such problems made assembly enormously difficult.

The point here is that earlier processes worked at whatever rate suited them. Parts were being made in a "no-control" situation. As a result, assembly could not get under way until the 17th or 18th of the month. By that time, just about every late part would have arrived. At the time, we used to say that, in the same way that a year of a sumo wrestler's life is compressed into 10-days worth of fights, we were in the position of doing a month's worth of work in 10 days. That fact alone meant that there was no way to meet monthly production quotas without three times the number of people on the job. I concluded, therefore, that one-third the labor could do the job if we "leveled" assembly work by distributing it evenly from the first day of the month to the last.

When I worked with assembly in the beginning, I argued that having parts there when we needed them should allow us to get by with one-third the number of workers. This meant that a threefold increase in productivity could be secured simply by having parts delivered "just-in-time." I figured it would be a cinch, and, in fact, when we actually tried it, we found that — depending on how we calculated — we could raise productivity many times over. With a couple of additional energy-saving measures, we had no trouble at all increasing productivity by a factor of five.

When you come right down to it, though, improvements are not going to increase productivity very much in something like assembly, which, if not labor-intensive, at least requires that some work be done by hand. Even so, you approach automation if you can have one-third the number of workers turn out the same number of units as before.

What I mean is that in the previous 20-day period, workers thought they were working pretty hard even though the line was stopping and starting all the time. The Japanese are nothing if not diligent. If the line stops because there are no more parts, they will go sweep up somewhere to keep themselves busy. Even when not working, they have the illusion that the job is getting done because they are expending energy.

Everyone confuses motion with work. As a result, we look only at results and tend to assume that a threefold increase means that productivity has risen because of a terrific intensification of labor.

18

The supermarket system

The automobile business gradually shifted its approach. However, I think it would have been helpful then had we realized that productivity might increase all around by adopting the kind of autonomation already developed for spinning.

At the time, a single person would oversee 20 or 30 Toyoda power looms. Everything was fine as long as all the machines were running. Whenever a loom stopped, the operator would run over to the machine, reconnect the thread, and restart the loom as soon as possible. When another loom stopped, the operator would do the same thing. In this way, depending on the type of textile involved, a single worker would be in charge of 20 to 30 machines. In essence, the human element was out of the picture while the machine was running, only intervening when the machine stopped.

If we transfer this idea to automobile production, a single operator ought to be able to handle 10 machines or so. That would mean a tenfold increase in productivity. Now, in fact, this is not quite the case, but in broad terms this concept is the cornerstone of the Toyota production system.

In 1951 or 1952, the first of our co-workers who had visited the United States returned home having taken numerous color slides. He explained to us that, in America, there was a type of store called a "supermarket" where there would be just one cashier at the exit. Shoppers would come in and pull around carts that looked sort of like baby carriages. They would select only the items they wanted and pay for them at the exit. The costs saved allowed customers to buy things at

lower prices. It cut back on expenses for the store, too, for one person could run the entire operation. The store made money even though prices were quite low.

My colleague's description may have suggested to me the idea of one process "shopping" at an earlier process. Anyway, about 1952 or 1953, I launched a new approach we called the "supermarket system."

At the time we had a weakness for English phrases, so rather than calling this new method the Ohno production system or Ohno line, the term "supermarket system" became quite popular. In due course, customers ("later processes") would come to the store looking for the items they wanted when they wanted them and in the quantities they wanted. In other words, the supermarket was practicing just-in-time. This seemed to me to be an ideal production system because customers, too, could live more economically by buying in accordance with the sizes of their own refrigerators and wallets.

What with neighborhood vendors, delivery boys, and whatnot, commercial practices in Japan until that time had been very favorable to customers — but costs had been climbing. Take the case of tofu, or soybean curd, as an example.

Each morning after making the tofu, the tofu seller used to walk around the neighborhood blowing a little horn and selling his wares. The product was very fresh and it was delivered right to your door. On the other hand, if you held off buying your tofu until the next day when you wanted to use it to make miso soup, you would be in a panic if sales had gone well and the tofu seller had none left by the time he got to your house. At first glance, the Japanese lifestyle may have seemed convenient, but it tended to be impractical.

In this sense, a supermarket is exactly the opposite because it is the customer who gets into a car and goes shopping. Compared to the Japanese idea of service, this is entirely backwards. If you are having someone deliver scallions to you, you order a whole bunch instead of the two you need because you cannot ask someone to bring you just two scallions. And while you are at it, you order a large white

radish, so in the end the system is uneconomical. The exact same thing happens in production plants. When an item is finished it is taken to where it is going to be used. Some may think this is good service — but, in assembly operations, to have parts arrive at random as soon as they are made is an impractical way to do things.

It is the easiest thing in the world to raise productivity by a factor of three if the same operation is conducted properly. This is where just-in-time comes in. The system tells earlier processes how many units of what item to make, so that only as many items are produced as will be sent to subsequent processes. If only 10 parts are to be delivered, only 10 parts are made.

19

Without Toyota there would be no kanban *system*

In the initial supermarket system, earlier processes constituted a kind of supplementary system. Since assembly withdrew the parts it wanted, the earlier processes only had to make that many parts before assembly returned for the next batch. The numbers of various parts taken by assembly were indicated by chits known as *kanban*, so a kanban showing that 10 parts had been taken would become an order for 10 more parts to be made.

The processing side of things was more or less straightforward, but lead times, lot sizes, and other variables still had to be taken into consideration. The big problem for earlier processes was how best to produce only the number of items withdrawn. It was clear that setup times had to be shortened as much as possible. And we could not apply just-in-time production if we had to fumble around in the dark for something that had taken an hour to make.

We wanted to use smaller lots which meant incessant setup changes. Setups had to be reduced to an absolute minimum for just-in-time to work. Indeed, so-called SMED setups became essential. [SMED, or single-minute exchange of die, is a method of reducing setup times developed by Shigeo Shingo and described in his book, *A Revolution in Manufacturing* (Cambridge, Massachusetts: Productivity Press, 1985).]

At the time, though, workers would never have gone along with such a zany idea. I was worried, too, that the people at the top would look at my unusual methods as dangerous ones with uncertain outcomes. Normally, such

people would have been afraid to let me go ahead, but Toyoda Eiji, Toyota's chairman of the board, and his advisor, Saitō Naoichi, resolved to let me continue. Their efforts gave a tremendous boost to the development of the Toyota production system.

I truly believe I would not have been allowed to do what I did had I been at any company other than Toyota. One might even say that it was thanks to Toyota that the system was completed. This is why it was named the Toyota production system around 1961 or 1962. Prior to that time, it was too dangerous to name it after the company because a single false step might have brought the entire firm crashing down. So until then we referred to it as the Ohno production system.

What that meant was that whenever I wanted to do anything in the plant, the people on the shop floor would always be discussing what the daily output was or which methods were being applied where. All this time it was the Ohno system that was the focus of attention, and, until about 1955, I almost had to be ready to commit *seppuku* in disgrace if I made a single mistake. I naturally expected considerable resistance at the time but, in any event, the people in management just did not understand what I was trying to do. The workers understood even less. Everyone was worried that we might do something to ruin the company. Still, I figured that the Japanese automobile business would never get on its feet if I failed to see the project through.

The focus of our efforts in those days was to raise per capita productivity. Even today, this remains the basic goal of the Toyota system. Following the oil crisis, a lot of people started wondering whether high-volume production was, in fact, possible. There was a great deal of talk about scaled-down production. Until then, high-volume mass production had been the focus for many years. All we had to do to raise productivity was to increase output. All we had to do, we believed, was turn out 10 times the volume with the same number of workers. Looking back at it now, it was all very simplistic.

The just-in-time concept was linked to kanban, but at the time kanban as an idea had not yet occurred to me. The traditional way of doing things typically called for parts to be transported to later processes as soon as they were made. And what did just-in-time do but stand this on its head — a process that needs a part goes to an earlier process to get it. It is that easy. No trouble at all.

Just-in-time represented an ideal that, according to the conventional wisdom of the time, was unattainable. Nevertheless, I insisted on talking about "postconventional wisdom," perhaps because I have a contrary streak in me and tend to look at things backwards.

When I was a child, adults would often get angry at me, but I was just trying to look at everything from various angles, from other people's perspectives as well as my own. Look at the case of monthly output. People figure they are doing their jobs when parts made at their processes pile up in a warehouse. They may insist their work has been done, but a glance at final assembly will show that not a single car has been completed. Regardless of how many hundreds of engines are produced, they amount to nothing without steering wheels. And you cannot have cars without rear axles or chassis. I think being in assembly was a good learning experience for me.

It was around 1955 that we actually set the kanban system in motion. At the time, I was still a division chief and could only do things within my own division. In 1955, I was with the machining plant that would now be referred to as the machining division. Then, however, people talked about there being three plants — the machining plant, the assembly plant, and the body plant. Someone else was in charge of the so-called formed-materials section, which included such things as casting, forging, and heat treatment.

At any rate, the first kanban could only be used in the machining plant and assembly sections, or between body and assembly operations. When I became manager of what is now known as the company's main plant, however, in 1962 or 1963, I acquired responsibility for formed materials

operations as well. For the first time, we began using kanban throughout the plant. Until then, the fact that different people were in charge of different operations made it very difficult to go to another part of the plant and tell people how to do things.

Before becoming manager of the main plant, I was at the Motomachi plant for about four years in the early 1960s. There, I put as much of a kanban system into effect as I could. For various reasons, however — among them the fact that our materials came from the main plant — kanban could not be put to work throughout the Motomachi and main plants. After all, a kanban system is supposed to apply throughout a company. It was a little bewildering for the workers in the plant, but I tried to minimize the confusion to parts subcontractors and affiliated plants.

This is an extreme example. What it means, however, is that while at the Motomachi plant, I was only using a kanban system locally, applying the idea last to parts coming in from outside. Unless a kanban system is running smoothly within an operation, there is no way it can be used for items from outside.

When I returned to the main plant as plant manager and someone else became manager of the Motomachi plant, the fact that we had only a partial kanban system caused a great deal of trouble for parts manufacturers. They told us that we could not do kanban halfway and said the kanban system at the Motomachi plant should be abandoned for a while.

20

What Toyota do Brasil *taught us about forging setups*

In putting a just-in-time system into practice, forging poses the ultimate challenge in terms of setup changes and reducing lot sizes. Casting turns out to be not so difficult. The only problem is the illusion that it is maximally efficient to keep doing the same thing over and over again.

In hot forging, red-hot steel is placed between dies and hammered. Because heat is used, the temperature of the dies rises to a certain extent as well. The material is cut into appropriately sized blanks and then heated. If heated too much, the blanks will melt, and if they are insufficiently heated, the machine will stand idle. During the actual forging, a kind of oxide film or residue appears. Adjustment of the dies on a forging press or hammer is extremely difficult when this residue spatters.

In general, the first thing you do is secure the upper and lower dies and make a trial forging. You then measure the result, correct any die offset, and regulate the height. The dies are usually in place after two or three trials, but the process involved is the most time-consuming element of a forging setup.

Once the dies have been changed, it also takes a considerable amount of time before forgings are produced. At Toyota, forging setups were the slowest of all. All this leads to the inevitable conclusion that forging must be carried out in large lots.

As we were grappling with these issues, Toyota's Brazilian operation acquired a forging machine and began to do its own forging even though it had only the one machine to forge some 60 different items. With a daily output of only

two or three assembled vehicles, moreover, this was the world's smallest automobile company. Monthly production even now is about 400 cars; at the time it was 40. As a consequence, no one in Brazil was willing to do forging for them.

In forging, it is common practice to accept only minimum orders of 1,000 pieces. With a need of only two or three pieces at a time, the company didn't know when it could have the forgings made. On the other hand, 1,000 each of 60-some parts would amount to several years' worth of inventory. They only needed two per day, or perhaps 40 per month. To order 1,000 parts and not know when they might be used — maybe six months from now — would have led them into bankruptcy. Recognizing this danger, the company decided to install its own forging machine and make all 60 parts on the premises.

If you are not going to forge more than 10 pieces at a time and each setup takes an hour, then eight setups a day will bring production to zero. This is why the first instruction they were given was to figure out a way to reduce setup times from one hour to 15 minutes. With 15-minute setups and 15-minutes' worth of forging per part, they could handle two parts an hour. This meant managing with 16 dies. With the goal of producing 60 items in lots of 10 per week, we had *Toyota do Brasil* look into the question of forging setups.

Happily, *Toyota do Brasil* gave the job to a Japanese-Brazilian who they were confident could find a solution. If a Japanese company had given the same instructions, it might not have been successful. There is a world of difference between Brazil, where a task seems possible when some bearded, overbearing guy comes from Japan and tells you to do it, and Japan, where you don't do it because you don't think it can be done. At any rate, they managed to reduce setups to 10 minutes. This led to a number of suggestions.

By making preparations during so-called external setup (while the press is running), dies could be slid into place and the next part produced within a few minutes. It was felt that guides could not be attached to the machine because the res-

idue produced by the forging process would adhere to the guides. Yet without guides there was no way to produce acceptable parts from the first strike. So it was decided to attach guides anyway.

These guides spring up when needed and are not used when forging. They are in place during external setup until the dies are mounted. Heights are also adjusted while the press is running — one glance at the guides assures that forgings will be satisfactory. After all, if you are only going to forge 10 pieces, it is absurd to turn out two defective ones in trial runs. We made the dies here in Japan, but they mounted all the guide pins in Brazil.

The system worked beautifully. With a single forging machine, they produced over 60 different parts without a single defect. It was our turn now to go there to learn about forging setups, so two or three people from Japan made the trip to Brazil. From that point on, the approach caught on in Japan.

Going to Brazil made us realize that castings are not so difficult either. Castings, after all, are made by pouring molten steel into molds. Even though one ought to be able to cast different items one after another, one tends to fall prey to the illusion that using the same die again and again is somehow more efficient. Moreover, different materials have different properties — some are malleable and others are more like ordinary slag. When lots are large at the melting stage, however, you in effect end up working with substantial amounts of the same material. It takes time, trouble, heat, and everything else to melt different materials in short order. The whole business is pretty tedious.

With an operation the size of Toyota's, however, "in short order" does not mean you are suddenly producing 1,000 or 2,000 parts. In this respect, increased quantities means less anxiety over setup changes. On the other hand, *Toyota do Brasil*, as I just mentioned, makes a variety of parts in minimal quantities. The result is that they give due consideration to melting all materials together and then figure out how much in the way of additives are needed for each run.

In this respect, *Toyota do Brasil* serves as a model or case study of the best practitioner of the Toyota system. When it comes to the kinds of numbers involved at Toyota in Japan, the best aspect of the Toyota system is that you can get along without it. For any given body type or part, you already have a production line set up and, quite frankly, there are hardly any setup changes to deal with. We have gradually reached the point where we do not need to change press setups after every five or ten parts. This is precisely why I think *Toyota do Brasil* may be the company having the most success with the Toyota production system.

No matter what one might say, however, outfits dealing in small quantities cannot keep costs as low as those who practice mass production. Even so, they are showing substantial profits in situations where most people would expect them to be deeply in the red.

The fact is that when we began using the Toyota production system, Toyota was building a variety of types of cars at a rate of 3,000 to 5,000 per month. It was not a high-diversity, low-volume operation — "medium-volume" is more like it (although, of course, some products were "low-volume"). Originally, then, the Toyota production system was a marvelous method used in a medium-sized company. The Toyota system, in other words, grew to maturity being used with an output of 2,000 or 3,000 vehicles. But a modern mass-production outfit like Toyota today does not need the system to make products cheaply.

21

Rationalization means conforming to reason

In the course of promoting the Ohno system, I talked to some people who had a great deal of trouble understanding what I was saying. When this happened, sometimes I asked them to leave the room, to go wherever they wanted if they couldn't bring themselves to listen. "Go do something," I'd say. "And don't worry. I'll take the responsibility."

In the plant at that time, you might have a group leader answering to a department head, answering to a section head, answering to what would now be called a division head, and you might never know when something would get done. I did not talk directly to workers, but, given this situation, would skip the people in the middle and address myself to the foremen who were right at the cutting edge of things.

I was impatient, for one thing. And ideas are distorted when 10 or 20 people repeat them by word of mouth. Similarly, I could not get my ideas across completely going through the standard chain of command. People at each level applied their own judgments or interpretations, totally changing the concepts as they moved downward. I also abused my authority by listening directly to what people at the foreman level had to say.

Middle management offered tremendous resistance — but these people warmed up when the plant manager told them to get going. When upper-level managers would not listen, however, middle managers had to report everything I told them to do to their immediate superiors. In contrast, they did not have to tell me directly what they were doing in response, their results, or anything else.

Given these conditions, I educated people about the system at the top and the bottom simultaneously. Thus, some people's superiors became angry that they were not reported to immediately although I also addressed myself to them directly. It made no sense for those immediate superiors to report only that they had heard something from me. "Have them do whatever you want," managers would tell me, "and I'll get mad if I don't like it!"

No one understood the Ohno system because it was not being practiced anywhere. If results turned out all right, things were fine. But if something went wrong, changes had to be made. I would go in the morning and give various instructions. Even though those instructions may have been followed when I visited again that afternoon, we would have to change things right away if the results were not good. So a certain amount of wavering was unavoidable. For this reason, I often told technical people — who are inevitably rigid — not to cling to specific ideas, reminding them of the saying, "a wise man knows how to adapt." "Learn to adapt," I told them. "Be wise!"

If the Ohno system had been in operation somewhere else, I would have taught everyone by taking them to see it in progress. But the method was not being applied elsewhere. And even if it were, we would never use it any better unless we made some major changes.

Some time ago, when we were still exchanging visits with Nissan, I responded to reports about what Nissan was doing by telling our people we had to come up with even better methods. Yet at the time, Nissan's methods were better than ours, so the first thing our people tried to do was imitate the Nissan approach. Realizing it would get us nowhere, I more or less terminated the visits to Nissan. And before long, Nissan decided they no longer wanted to show us their operations.

Before the war, Nissan kept the plant it had purchased from the United States and apparently retained some American technicians. In that sense, Nissan may have been considerably more advanced than we were. However,

when the Americans went home, soldiers were pressured to produce quickly. The military supervisors withdrew after Japan's defeat, but the old ways persisted. They had a good deal of technical knowledge, but things got to the point where Japanese workers would not listen to what another Japanese said.

When first shown American plants in 1956 or 1957, I saw nothing I hadn't expected. I visited them all — General Motors, Ford, American Motors. Even on "streamlined" or "rationalized" production lines, there was nothing the least bit startling. From the point of view of a disinterested third party, the more rationalization progressed, the more the Americans appeared to be doing things the way they ought to have been. Indeed, something might have been amiss if things had appeared startling. Perhaps the best-run places are those that hardly seem to merit attention.

In the final analysis, however, rationalization means doing things in conformity with reason, so by rights it should hold no surprises. I am saying that things should be as one would expect them: round objects are most easily rolled and heavy objects can be moved more easily when rollers are attached.

We shouldn't spend too much time thinking about rationalization because a perfectly rationalized situation would be an extremely simple one. For example, reducing inventories and work-in-process is rather odd in terms of rationalization. By rights, a rationalized operation should have no work-in-process at all. Isn't it contrary to reason to carry two items when you only need one?

22

Don't hesitate to shut down machinery

The work done by an autonomatic loom is distinct from mere motion. As I tell people, a machine may produce any number of defective items but that doesn't mean it has been working. Making defective products does not constitute working. The role of autonomation is to stop a machine when defects appear, to avoid making defective products. That is the difference between autonomation and automation.

"An autonomatic machine is a machine equipped with an automatic shutdown mechanism." This definition is one I happened to hear and remember from my student days when I majored in mechanics and attended several lectures on spinning.

Thus, "working" is equivalent to an automatic shutdown mechanism. Nowadays, we would call such a device a sensor or some other technical term, but in any case the main idea was that it had to shut down the machine. For several decades, this idea stayed alive in my mind.

Autonomatic Loom Works was located in Kariya, a suburb of Nagoya, and the teachers in the spinning and weaving department of Nagoya Industrial High School studied autonomatic looms a good deal. Indeed, had I been a student elsewhere, I might not have heard this definition.

In the absence of an automatic shutdown mechanism, the machine operator is compelled to turn off the machine. Sensors cannot always be used everywhere in an assembly plant, however. Where they can't, the worker who notices a problem is the one who pushes the *off* button. This arrangement turns an ordinary assembly conveyor into an autonomatic conveyor.

I once went as a consultant to a company whose president remarked, "When Ohno gives advice, he tells you how to turn things off instead of telling you how to make things."

But there is really no way around it. I tell workers to turn the machine off if they discover a problem because once it is off they can look for a solution. Thus, the first step in autonomation is to come up with a way to shut down machinery.

How do you detect an error and then automatically turn off a machine? Final assembly lines at Toyota have autonomatic conveyors. These cannot perform automatic detection, but they will stop as long as the operators are quality-conscious. As a result, there are *off* buttons everywhere. The person who discovers a problem stops the conveyor. Since considerable losses are incurred when a machine stops, figuring out how to continue production without stopping is clearly linked to quality improvement.

Visitors to Toyota find it most strange that workers are free to halt the final assembly lines. This cannot be found anywhere else in the world and, outside Toyota, I imagine it is fairly rare even in Japan. When Hino and Daihatsu became affiliated with Toyota, the first thing we told them was to install *off* buttons. The second thing we said was to make it so the buttons didn't even have to be pushed for the conveyors to stop. Daihatsu, for example, moved from "stoppable" conveyors to "self-stopping" conveyors.

Next, you have to figure out how to keep machines from being turned off. When we were first starting out, I used to tell people at the Motomachi plant to turn off machines if they grew tired. If they did, I would ask the group leader or foreman why the workers had been given such tiring tasks. They would say that workers turned off machines because they were attaching defective parts. "Well then," I would ask, "how can you prevent them from attaching defective parts?" And finally, I would say, "You've got to think about situations where you can't turn off a machine even though you want to."

Safety and quality are fundamental issues. Since producing defective goods does nothing but increase costs, it follows

that quality control is basic and essential in terms of lowering costs. This is why, when we had to cut costs in 1955, our top priority was to reduce defects. Costs will come down to the extent that defects are reduced.

23

How can
we make things
less expensively?

When we started out in the passenger car business the Crown cost over $2800. Then president of the company, Mr. Ishida was called up before the Diet and told that Japanese cars were too expensive. There was even a contingent of seers who suggested that we would be better off buying inexpensive cars from the United States than trying to make them ourselves. At any rate, our number one priority at the time was to lower costs. Japanese cars were too expensive and somehow we had to make them cheaper.

Even before that — in 1949 or 1950 — Mr. Ichimata, a Bank of Japan governor, had said Japan should not be building cars, that it was better to buy them from America. At that same time, Toyota started to go under.

Given the situation, finding ways to cut costs became the highest priority. The perception that it would not be economical for Japan to build cars was left over from the prewar era. Thus, it was argued that we would not be much different from the United States in terms of wages if we were to raise productivity — for example, if we increased labor productivity tenfold.

In those days, it was pointless to lower prices through mass production because there was no accompanying market demand. Toyota started to go under in 1949 and 1950, because even when we made 1,000 vehicles a month we were unable to sell them. That shows how weak the Japanese economy was in those years. So when Toyota drew up a reconstruction plan, it was designed for fewer than 1,000 vehicles per month — I think it was 940 — because we didn't know whether we could sell 1,000 if we

built them. Labor disputes came to an end as we began reconstruction and, because this was just at the beginning of the Korean War, military procurement orders to Japan helped as well.

Up until that time, even if we had built 1,000 vehicles, we had no customers for them. Whether that was good or bad was a separate issue. We did not even dream of an output of 3,000. What is more, even with only 1,000 vehicles, we could not build just one model. Our reconstruction plan, therefore, allowed for something on the order of 60 passenger cars. Looking back on our situation, it is difficult to imagine how we could avoid angering people with $2800 cars.

Even so, the company would have foundered had we made thousands of passenger cars and been unable to sell them. When Mr. Kamiya, president of Toyota Motor Sales, told us we would have to manufacture about 1,000 per month if we were to export the Crowns to the United States, we wondered how we would go about producing so many. This was around 1955. Today, the subject would be hardly worth mentioning since we build 1,000 cars in the space of minutes.

The Toyota production system was extremely effective in helping us get back on our feet. Even as production rose later on, however, the system seems to have remained totally unknown to the public at large. The Toyota production system only came into the limelight in 1973 or 1974, as the company continued to show profits even in the years of scaled-down production following the oil crisis.

If we had not suffered the tribulations we did, the Toyota production system might have been modeled on the American system. Like the Americans, we might have had to sell tens of thousands of vehicles in order to bring out a new model every three years, or we might always be investing in equipment, with no end in sight.

When some people from Daihatsu came to us for training after the establishment of the kanban system, I told them they had to produce only as much as necessary. One of the trainees asked if it wouldn't be a better idea to produce as much as possible as long as time and materials were still available.

"Not so," I replied. "Make only what is needed. You may have materials left over, but it does the company no good if you make 120 items when you only need 100." If you only need 100, only make 100. On the other hand, I told him to set up the processes so that it took a full day to make those 100 items. (There was a big problem at one point during the war when the workers all went home at noon after having produced their daily quota.)

Thus, in the process of figuring out how to produce cheaply only what you need, one essential point is to ensure sufficient work continuity. If the job is done by 3 p.m., people will protest that it is wasteful not to go on producing when they still have materials available. In fact, though, the least expensive way to do things is to provide numerous processes so that 100 items (if 100 are needed) take until 5 p.m.

Actually, Toyota's basic formula of making *what you need only in the quantity you need when you need it* has another element: *as inexpensively as you can*, but that did not get written into the slogan. You make what you need only in the quantities you need and as inexpensively as you can — that is the Toyota production system.

Although it would be a mistake to give top billing to "as inexpensively as you can," there are a number of ways of producing things cheaply. One is to make only 100 items if you only need 100 — even if you could make 110 of them before quitting time. That would end up being more expensive.

The most difficult part of the Toyota production system is learning to make those 100 items inexpensively. For this, everyone involved must study how just-in-time allows you to produce things more cheaply.

By giving top priority to making things inexpensively, you could end up with several results: overproduction, underproduction, faulty timing. There's really no end to considering ways to produce inexpensively in the Toyota production system.

Yet in the process, you will have a hard time fitting tasks together. In the final analysis, breaking off at 3 p.m.,

working people overtime, or leaving jobs unfinished are always undesirable. Yet, if you leave out the question of inexpensive production, the job will not be over and your product will have a terrifically high cost.

The Toyota production system studies how to make products inexpensively under conditions of restricted production. Some argue that you should ignore restricted production and try to lower prices through mass production or, that when you have five workers available, it is better to make 200 items than 100. The Toyota production system rejects such thinking.

24

Don't succumb
to the
robot craze

The phrase "limited production" dates from the first oil shock in 1974. To a certain extent, things were easier before that time because we could sell as many cars as we could make and the focus was on inexpensive mass production. In 1974, however, automobile production saw a temporary decline. Indeed, many industries continued to decline. Automobile-related businesses, however, did not get the message. It never crossed their minds to cut quantities; they simply produced when orders came in, without paying attention to whether prices went up or down. With a little exaggeration, we could say this attitude persists today.

Starting roughly the same year, automobile production began to be constrained by trade frictions and so on. Although one might promote sales domestically when exports are restricted, domestic sales cannot be expanded indefinitely. Companies that fail to produce limited quantities as inexpensively as they can will surely regret not having done so. In their experience, you see, one lowers costs by increasing output.

The essential question here, however, is how to make things at low cost. This has to be the fundamental issue. Without this basis, it's silly to think of improving performance with robots, automation, or anything else. Yet robots seem to be the rage, and people are installing them. They think their operations will look old-fashioned without them or that robots will decrease labor costs. Unfortunately, they give little consideration at all to whether their costs are rising or not.

It may look as though we are against robots, but in fact, you must move ahead — with robots, computers, and the like. At the same time, however, you cannot simply install robots and computers without considering the extent to which costs will decrease as a result. I don't know — maybe I'm not being very nice to the robot manufacturers.

Actually, an Englishman suggested that by the year 2000 we ought to have an international ban on all automation, including robots. Maybe we should even acquire our robots with that kind of possibility in mind to some extent, because otherwise we would be in real trouble if we ever had to give them up.

At a time when Japan was using robots and China was resisting modernization, the question was asked why China shouldn't use robots. But why use robots in a country as populous as China? It would be silly to use robots just so you could call yourself "modern."

Yet even in Japan, where robots and numerical control (NC) machines and so forth are selling extremely well, a real question is whether costs are really dropping as a result. It may not have been a problem back when you could sell whatever you produced. I am certain that, if not for limited production, in many cases the use of robots would reduce costs.

Using robots undoubtedly cuts labor costs. Things can be made much less expensively if you calculate manufacturing costs by the price of labor. And robots are used for tasks that are hazardous. Higher costs are inevitable in some such cases, but with the current robot craze, I think it is a little silly to go around looking for ways to use robots.

The truth is we *should* use robots, but the possibility of inexpensive automation or inexpensive robots seems to be an open question and an extremely important one. We have been saying this at Toyota for a long time. Toyoda Gōsei, Toyota's tire and rubber products supplier, too, has made a great fuss about it. Don't tell people that such-and-such a task can be automated, they say. The process of automation follows a certain order. It may be difficult, but it must be adhered to. Automating for the fun of it will only get you in trouble.

Needs ought to decide the matter, but sometimes people mistakenly treat appearances as needs — like my neighbors who bought a piano when pianos were all the rage. They were embarrassed that the home of a business executive did not have a piano. So, without regard to whether anyone in the family had any musical talent, they bought an instrument that became their pride and joy. That sort of purchase — one made to preserve appearances — is the kind we should avoid.

The primary need for robotization comes when it is known that costs have to come down. Next is the application of robots for hazardous work which, in spite of the cost, can be important in terms of respect for human beings. Some dangerous or unpleasant tasks, however, cannot be carried out by robots, so there is no alternative but to have workers do them. It is unforgivable, however, to show disrespect for humans by making them perform dangerous jobs just to keep costs down. We must also be especially alert to automation carried out for the amusement of engineers or improvement "experts."

If you really are short of people, it is true that, in terms of costs, acquiring a robot may be better than hiring workers. On the other hand, in a gradually aging workforce, I wonder how the cost picture would come out when robots work under the supervision of older workers.

Some people claim that, with rising salaries and an aging population, Japan may be moving into an era in which the absence of workers will demand the introduction of robots. Everybody has a different approach to the problem. For example, labor unions suggest that robots are taking food from workers' mouths. I think ideas like these are silly, but the problem lies in the popular tendency to think either that installing robots is progress or that robots will take away jobs from workers.

In the United States and elsewhere where workers clamor for higher wages, companies buy robots despite rising unemployment rates because they say robots do not complain. That may be fine for individual companies, but where will it lead as an overall trend?

25

Work is
a contest of wits
with subordinates

Managing a large group of people is grueling work, but basically, I don't think it has as much to do with giving orders or instructions as it involves a contest of wits with subordinates. I often tell people that when they give commands or instructions, they should imagine themselves receiving those instructions. And when they have lost a battle of wits, they should freely admit they are beaten.

When people reach the upper echelons of an organization, they tend to translate their hopes into instructions and commands. They may not have given certain problems any thought themselves, yet they tell their resident experts to think about those same problems or to set things right.

If managers are simply going to accept it when their experts come back saying that such-and-such a task is impossible, then, I want to tell them they should not issue commands of that sort in the first place. They may protest that their responsibilities are broad, that they're too busy to get involved, or that it is the experts' job to think about certain kinds of problems. This attitude, however, is wrong.

And, of course, if managers don't admit when they are beaten, their subordinates will eventually stop going along with them. No one will follow those who, for all their talk, always complain and say no.

You have to suffer along with your subordinates and think along with them. Give them as many suggestions as possible. Tell them you tried their idea and it didn't work. If they fail to volunteer anything more, ask them. Then give your own suggestion or idea a try. If it works, point out that

it's not really very well thought out but that it seems to be on the right track. The important thing is to project an attitude other people understand.

So I think — to exaggerate slightly — that what you have to work on is a sort of character-building. You have to be concerned that the other people are sticking with you. But there is a fuzzy area here. After all, everyone you interact with will be different, and a change in attitude will be inappropriate for some of them. Half of them may listen to what you say and the other half may pay no attention at all.

It's not easy to tell people to follow you. On the other hand, if they do, you must take responsibility and look after them all along the way. The key unit is the workplace. At Toyota, we figured that those who wouldn't listen to us could go elsewhere and were grateful to and cooperated with the people who went along with us to the end. And, believe me, we didn't always do things right.

26

Offices without supervisors

Although I've been talking about the workplace, the same lessons apply to office work as to the production shop. When it comes to business matters, our principle of "workplace first" (*genba shugi*) also refers to the business office. Yet not everyone looks at the office workplace.

Places where things are manufactured are relatively open to view. Business offices, however, are extremely difficult to observe. This is because people can be so intent on their work that they have no way of judging whether that work really needs to be done or not.

In an office, no one — not even a manager — has sufficient wisdom or knowledge to be a "supervisor." In fact, *everyone* is a manager. Indeed, in the realm of office work there are no supervisors, but we need them — we need people in supervisory roles to provide guidance.

How then do we assess the results of work? People we call supervisors in Japan have not really supervised work in a long time. Far too many of them simply watch people working. Whether in the production shop or in the business office, this is a nearly universal error. Supervisors must supervise the progress of work being done. Improvement is definitely needed if supervisors only watch workers move around.

From our point of view, supervisors are in a tough position. Managers can get by with knowledge alone. Supervisors, however, require more than knowledge. They must also have the ability to teach, to show others how the job ought to be done. To supervisors, management is a world apart because managers do not see work actually carried out.

These days at Toyoda Spinning and Weaving one hears a lot of brouhaha about the speed of workers' hands. I tell people never to let such concerns engulf them. You may think your workers are doing a good job, but you are not really talking about work — you are only talking about manual speed. If you allow yourself to be carried away by the issue of manual speed, you will fall behind in automating. If you concentrate on whether it might be more efficient to have women do the job or on the speed of their hands, then you are trying to supervise motion. You are not supervising work.

A supervisor plays an important role akin to that of a manager in professional baseball. Various issues must be dealt with. Clearly, your team manager can't be totally incompetent. Then there is the question of whether those who were fine players in their youth necessarily make good managers. Finally, good managers must know each of their players well. Team managers cannot really run the show without a thorough grasp of every player's personality and skills. Supervisors will not win games if all they do is stand by and get angry when their players do not do what they think they should be doing. Whether in production or in office work, creating good supervisors is an important task.

White-collar workers, however, are on a fast track, often rotated from one job to another. This can mean that no one is seeing to the why's or wherefore's of work. These people stay in one place for a few years and then move on without anyone paying much attention to what they have accomplished.

What happens, then, both with supervisors and managers, is that people make little effort to show an improvement over their predecessors — just the kind of attitude you would expect from a bureaucrat. People figure that, having worked a little while in one place, they will go elsewhere and become section heads or, after a few years as section heads, that they will eventually become division managers. They are not interested in being able to say that they managed to perform the same work as their predecessors but with two or three fewer workers.

This is a problem even at Toyota. No matter how much I talk about "rationalizing" business operations, people just go on doing things irrationally whenever anything out of the ordinary comes up. If things were truly rational, section heads or division managers with lots of people under them would be judged on the basis of what they accomplish. But that is not the way such things are measured.

Will a new section head try to accomplish a task with 40 people that his or her predecessor did with 50 people? Or will someone who has been in the same post for two years running take pride in having 40 people this year do a job that required 50 people last year?

But people don't measure work that way. With that kind of attitude, what kind of progress will section heads make? And why do their salaries keep going up? Unions. I guess we are caught in a bind.

27

Things
can always be
more rational

The production workplace might make a fair amount of progress toward rationalization. Yet even though it is more or less taken for granted that administrative offices are a good deal behind in such matters, there is still plenty of room for further rationalization in the production workplace. The potential is there, but actual results may diminish because they will be determined by the efforts made.

That last little bit — that last 1 percent — cannot be accomplished no matter what efforts you make. This is why people do not notice how incredibly rational something like production leveling is. Even after leveling, they want to know whether something more can be done, whether there might be some procedure that would improve things further.

For instance — in assembly production, only the number of items assembled are usually considered. Assembly involves a variety of parts, however. For each one, the person responsible for the part may figure that he or she has increased efficiency. Because reliable calculations can be made from the number produced, that person may well think there is no room left for rationalization. If you produce 120 items when you only need 100, you might think that rationalization has improved productivity. But in fact, there is nothing rational about it. At that point, you must give some thought to producing 100 items with fewer people.

It is important to tell people to make things in sets, even though calculations tell you that working with sets makes things more expensive. Even though the actual product might be cheap to make, the individual parts are expensive. Suppose you already have this month's quota of engines and

they have all been completed very efficiently. A look at the workplace tells you everyone is working well.

But it doesn't matter how efficient the workplace appears — you will not get a single car off the line until the differentials come out. So while assembling one engine, you also make one differential, one front end, one steering wheel, and one frame. Production management has to address itself to how to best control these various processes.

People may talk about individual cases, how well they are turning out gears, how cleverly they are using robots, or how they can do such-and-such a task with only three workers. But none of these things can be sold until they form an integrated set. *Making only as many as will sell* is easy enough to say, but in practice there is nothing more challenging.

In forming sets, overproduction is extremely troublesome — it throws the numbers off. "Waste" is hardly adequate to describe the effect of overproduction or excessively early production. Proceed with the understanding that such actions harm the company and that there will always be plenty of room for improvement. But if you just go by the numbers, then you should not expect too much from rationalization.

This is why people have a hard time understanding that it may be more profitable to the company to make 100 items than to go all out to produce 120. Obviously, you need to reflect a bit on the fact that you are supporting enough people to overproduce by 20 percent.

Think what might happen if we looked at office work from the same perspective!

28

Be a boss people can count on

I never get angry at ordinary workers. On the other hand, I get furious with supervisors and those higher up. The workplace is conducive to anger. It is a noisy environment where people have difficulty hearing what others are saying. When I get mad at a supervisor in the workplace, the workers naturally feel sympathy for their boss who is getting yelled at. That makes both supervisor and subordinates more apt to be careful. The message would not be as effective if I were to take a supervisor aside to vent my anger. Since we are in a noisy place, I can just yell away and the person I am shouting at need not even know why I am angry.

On the other hand, the workers are aware that their boss is getting yelled at and will wonder whether perhaps they have been doing something wrong. The result is that the next time their supervisor tells them something, they will be inclined to pay closer attention.

When I first became a supervisor, a senior colleague told me that our boss never gets angry at people under him in the presence of the other workers. He takes them aside and yells at them. I was told, then, that I should not yell at supervisors in front of workers, yet I ended up making a point of doing exactly that.

A person who is criticized for something really significant will lash out as well. On the other hand, if you just yell at someone for no particular reason, that person will be unable to relax. Nobody likes being scolded in front of others; on the other hand, the experience can make it easier to get through to subordinates.

This will only work in the workplace where people have gotten to know one another over a long period of time. For people in the workplace — especially those directly performing work — to go about their jobs with enthusiasm, they must have people around they can rely on. If there are work leaders in the workplace, it is a good idea not to change those leaders too often. If one of them is promoted to foreman and acquires broader responsibilities, more people will come to rely on him or her. After a year or two, however, workers in the original group will get the feeling that their leader has deserted them.

In this respect I sympathize with blue-collar workers. They want to be able to count on someone, but the people they do rely on are always being shifted around. There is no sense of mutual reliance among white-collar employees because they are all busy advancing along their own tracks. By the time they reach retirement age, they may want to go somewhere and help out, but by that point they are not very useful.

Workers see white-collar people shifted around all the time, including the most conscientious boss who moves on to a plant managership and leaves everyone else to stagnate. There is always the chance that someone new may be coming along, but in this climate, it is little wonder that the workplace loses its vitality. If white-collar people do their jobs well every day, they eventually move up the ladder.

Unfortunately, this system makes ordinary shop hands feel the disadvantage of their status. In the long run, there will be a world of difference between the productivity of people who work with enthusiasm and that of people who are happy just to see another day come to a close.

Once as a plant manager I did something rather unkind. I asked for a staff member — a shop technician — to be summoned and he came right away. Then I told him what was on my mind.

"If I really had something I wanted taken care of, I'd be the one who'd go to see you," I said. "The fact that you could come so promptly when I called you means that no-

body in the shop is relying on you. Suppose you really had to be called out of the workplace. Even as a plant manager you would be unable to come so fast if you were busy trying to solve some problem the people in the shop had given you. If what I wanted to talk to you about was so urgent, I'd have gone to the shop to see you. It's absurd for you to come rushing in all perspiring and stand at attention in front of me. It must be that no one in the workplace is counting on you."

People supervising the workplace ought to be doing things. They will come up with good ideas if it's expected of them. Indeed, as long as they are expected to contribute something the next time they show up, workers will call on those people to help them with problems they run into. Some of these people seem to have a lot of time on their hands and just stand around with vacant looks on their faces. If they are doing nothing to help anybody, no one will come to them with problems.

What you have to do is go into the plant and walk along at a rate of several hours per 100 meters. No one is going to rely on you as long as you cover those 100 meters rapidly.

"Why work standing up," you might ask a worker. "Nobody's going to complain if you're sitting down." If you have the worker use a certain tool sitting down because it is more comfortable that way, word will get around fast. People will talk about the supervisor who came along and showed them how to make their jobs easier. Then others will ask you to come take a look at their work stations. Pretty soon, you will have a hard time covering those 100 meters in the workplace.

29

Organization

orderliness

cleaning up

cleanliness

discipline

Organization (*seiri*) involves disposing of things you don't need and orderliness (*seiton*) means always having access to things you do need. Simply lining things up is merely arraying them (*seiretsu*). Workplace management demands organization and order.

Organization and orderliness are given a lot of lip service, but more plants than not fail to put these principles into practice. I mention the word "array" in connection with a certain plant I once visited that not only did not use a first-in, first-out storage system, but simply stowed all parts that came in from suppliers in a warehouse.

Things stayed there forever, from items made useless by planning shifts to finished goods. Whenever anyone tried to withdraw any outside parts for use in assembly, a staggering amount of time was needed to find and extract them. I told them they had to organize things and put them in order, and the next time I visited everything was neatly lined up.

"Haven't you got any idea of what organization and orderliness mean?" I asked. "Organization is like reshuffling personnel (*jin'in seiri*); it means getting rid of what you don't need. You're not organizing things properly if what you're doing is piling up unnecessary items in a warehouse just because you've gone to a lot of trouble to produce them."

Then there is orderliness (*seiton*). The characters used for writing the word tell the story. In the old days, the expression *tonpuku* [頓服] referred to a dose of medicine with an immediate effect. The first character, *ton*, of *tonpuku* is the second character in *seiton* [整頓]. The *sei* [整] of *seiton* means to arrange, so the word as a whole refers to arranging things so

that they can be brought out promptly. You have neither organization nor order if you are unable to get what you need without moving everything else out of the way. All you have done is neatly line things up.

Old military types use the word "array" (*seiretsu*) to refer to lining up in neat rows. If we are talking about two rows, then arraying means to line up neatly into two rows. Yet tell a group of people to "array" things and they won't know how to line them up. Drawing lines and specifying that they are not to be crossed, or saying that things should not be stacked above a certain height are fine — but they are totally unrelated to organization and orderliness.

We used to talk about the Four S's: *seiri, seiton, seisō* (cleaning up), and *seiketsu* (cleanliness). But there is no "s" for *seiretsu*.

Toyota used to go in for arraying things. In the early days of "Four S Competitions," company officers would make the rounds of the shops once or twice a year and confer awards on units that had done a good job with organization, orderliness, cleaning up, and arraying things neatly. Most of the competition was for "arraying."

But then we saw that this didn't work. The first item put in order would go on the bottom and, if we ever really needed to use it, everything on top would have to be taken off. Where is the orderliness in that? Gradually, Toyota moved toward real organization and order.

If one is not careful, cleaning up (*seisō*) and cleanliness (*seiketsu*) may amount to nothing more than a lot of paint. What is really needed is to make things clean — not pretty — just clean. In a machine plant, this includes having to sweep up cuttings and dust.

For a time after World War II, American influence led to the use of what we called "color conditions," in which the focus of cleaning up was on the color of machines. A distinction should be made, however, between that kind of cleanliness and the cleanliness I am talking about here. Then there was another "s" word. We have *seiri* (organization), *seiton* (orderliness), *seisō* (cleaning up), *seiketsu* (cleanliness),

and *shitsuke* (discipline). It is true that we tried to preserve the alliteration, but this last "s," discipline, is in fact quite important.

Back on the subject of cleanliness, the word "clean" (*kirei*) can have many meanings, but the key is to improve the workshop environment so people can feel good as they work. Everyone has to see cleaning up and cleanliness in this light. If employees figure they can leave the job of cleaning up to professionals, then no amount of cleaning up will ever keep the plant from being dirty.

Finally, we come back to *shitsuke* (discipline). In Japanese, the term usually refers to education, but there is something else to it. It is a difficult point to grasp, but unless you pay attention to that extra something, people will lose interest — discipline will wither — every time they start to feel a little sluggish. By the same token, we hear a lot of talk about etiquette on the golf course, but etiquette alone does not guarantee that things will go the way you want. And things only worsen if you fail to tell people what they should not do.

Schools nowadays are putting too much emphasis on scholastic ability and doing little in the way of discipline. In that sense, athletes are the ones learning discipline from their teachers and their comrades. But apart from athletes, we have an undesirable situation if we only promote scholarship and overlook discipline. I wonder whether the numerous instances of violence recently in middle schools is perhaps caused by letting students grow up without anyone seeing to it that they learn discipline. People working in large groups especially will find things get increasingly difficult when mutual discipline is not maintained.

There is no question about it — discipline starts at home. Since schools no longer offer moral training, parents must be persistent in pushing discipline. The trouble is, these days, both parents work away from home leaving children to become "latchkey" kids. Since school teachers do not teach them discipline, nobody does. And people who never learned discipline in school become parents themselves someday. As a result, their children never learn discipline either. Nobody will.

It doesn't have to be as rigorous as formal moral training used to be, but every day a child's parents, classmates, or friends ought to be giving some form of genuine moral guidance. People who get together and read books for an hour or so are not going to develop any real discipline unless they have role models.

Actually we need someone to nag us — and to act. Merely finding fault does no good. Developing discipline requires that people in superior positions nag not only those below them, but also their elders and one another. Talk by itself leads nowhere.

30

Improvement
adheres to
a certain order

Operational improvement (*kaizen*) means coming up with better methods using existing equipment. The important thing is to think of new work methods, not to make new tools or equipment.

There has also been a lot of progress made in terms of equipment recently, however. New machines may be brought in, but when they are, they must be used more and more efficiently. Suppose you bring in a robot. You have not used it effectively if it's just for convenience, if it's merely substituting for a worker. From the moment the robot comes in, it is vital to improve the robot or to change procedures to suit the robot.

You don't want a workplace where people say certain tasks are impossible unless you buy them a robot — or where they ignore the possibility of a method better than robotics. Introducing the latest machine has that much more effect when you find out, first of all, how far you can go with your current machines, and then how you can use existing facilities to get the best use out of the new machine. The more state-of-the-art machines you introduce, the more difficult it becomes to use them.

When I was a student, there was a camera around called a Pallet. The lens let in little light and the shutter was very slow. This was a camera you could buy for $3 or $5 when Leicas, for example, went for as much as $100. And the Pallet took good pictures, too. I still have a Pallet. If I were to give up on it because of its age, improvement would be impossible. Some people who cannot even use a Pallet correctly get a fancier camera, such as a Contax, and accumulate telephoto and wide-angle lenses and other accessories

thinking they will take better pictures. But their pictures do not improve. The more accessories there are, the more difficult to use cameras become.

We find the same sort of situation in a plant. The more high-tech or high-performance machines you have, the more difficult they are to use. It is true that once you have mastered a new camera, for example, you can take better pictures than the best ones you can ever get with a Pallet. This is why people who scorn the Pallet — and don't feel like taking pictures with anything less than a Contax — end up unable to take the kind of pictures the Contax is really suited for.

Many cameras nowadays are more or less foolproof — all you have to do is push a button. These are relatively cheap, too, so you really cannot go wrong. However, when you have to take a specific picture in a specific situation, this sort of camera may not be up to the task.

You could take that picture with a Contax, but if you give the Contax to someone who can't even take a good picture with a point-and-shoot camera, it is questionable whether he or she can produce a better picture with the fancier camera.

Another thing about improvement (*kaizen*) is that there are at least three or four different kinds of improvement: operational improvement, equipment improvement, process improvement, and so forth. I have not fully explained the meaning of the word "improvement" (*kaizen*), but what I am referring to here is operational improvement.

Improving operations comes first. If equipment improvement is next on the agenda, then equipment improvement comes next. Then you move on to process improvement. Improvement adheres to a certain order.

First, improve operations. Before giving up on old machines in favor of new ones you think will make the operation more productive, make sure there will be an improvement in quality. If you start out by bringing in the latest machines, people with no capacity for improvement simply end up being slaves to the machines.

People with no capacity for improving operations are a problem because they like to buy new machines all the time.

Buying machine *X*, they say, will make it possible to perform such-and-such a task with only two workers, or, with new equipment *Y*, one worker can do a job that five do now. You do not need to improve operations, they say — efficiency will go up more when you just go out and buy the new equipment. According to them, the numbers show that new machines pay for themselves.

In the same way, guys from Toyota's main plant were sent out to Kamigō or Motomachi when both plants were brand new. These people knew how to improve the old machines at the main plant and had been trained in the best methods around, but when they got to Kamigō, all they saw was state-of-the-art machinery. Newer plants are always like that. So as soon as they got there they set about improving the new equipment. They would look at something that had been set up a certain way and suggest a small modification that might make it even better.

Suppose you have a new plant somewhere. Since your high-tech machines can be run even by unskilled people, you recruit and hire unskilled workers who end up being slaves to the machines. You have completely lost sight of what will keep costs down in the final analysis. You must have the ability to tinker with and improve the machines you already have. If you only know how to use machines the way the manufacturer showed you, then you will end up with what you deserve. Only people unable to improve a machine they are given claim improvement is stupid and impossible without new equipment.

Next we come to process improvement. Here, things may get much better, for instance, if processes are reversed. Manufacturing processes generally follow one another, with an inspection process at the very end. But inspecting items earlier could ensure that no goods are defective. After all, it is better not to let a defect keep moving further down the line.

In a relatively large number of plants, for example, inspections come after products are finished, making inspection the last process. Quality, however, is built in at each

process, so that conducting inspections at that point may mean dispensing with a final inspection process completely, or it may mean that only a small section of the product needs to be checked at the end. Similarly, there are many opportunities for improvement when you are always alert to situations in which, for instance, it is more efficient to machine one thing before — rather than after — another.

It seems only reasonable that the person who makes something should inspect it. If a flaw is likely to show up in some item unless it is machined right away, then that much work is done at the current process so that proper handling further on can generate flawless goods. Elsewhere, products will go right through to the final process before the flaws are found. They get to the end and then drop out. Doesn't this constitute a tremendous loss?

In this sense, like the operational improvement discussed above, process improvement is pointless as long as people think it is all right to work in a daze because the technicians have decided on the procedures. Then there are people making operational improvements who see some opportunity for improvement and then assume that all problems will be wrapped up with that one change.

In terms of an order to follow, manual operations should be the first focus. Operational improvement is the most important step, out of which various things can result: you may see the advantage of modifying your equipment a little and end up seeing that even more would be gained by altering your processes. On the other hand, enthusiasm for operational improvements will suffer if efforts are spread out among people who see themselves as specializing in process improvement or equipment issues.

At Toyota, the expression "multi-machine supervision" (*tadaimochi*) refers to operational improvement that puts one person in charge of more than one machine. The basic Toyota philosophy clearly distinguishes between work carried out by machines and work performed by human beings. Human beings work at tasks that only they can perform. Taken to an extreme, that may be all they do all day. But the

idea is that people don't have to be around while machines are working. Out of this observation the idea of multi-machine supervision first emerged.

For example, a lathe may cut material that is fed automatically. The machine is not going to cut straight just because somebody is there watching it and it's not going to cut erratically because that same person has moved away. What we do, therefore, is mount the part to be processed on the machine, turn on the power, and press an automatic *run* button. The machine does the rest. It does not matter how many minutes a worker may spend watching the machine — when it is working, the human is not working. Time permitting, we tell the worker to mount or remove items for other machines.

In this way, the human does his or her work and the machine does its work. Before anything else happens, these two must be clearly distinguished. This means that *processing time* is not the same as *processing worker-hours*. This point is still the subject of widespread confusion.

Suppose we are talking about five minutes. How many of those five minutes are occupied by human labor? Let's say it takes 30 seconds to remove one part and another 30 seconds to mount a new part and press the button. It is the machine that is working for the remaining four minutes. So for five minutes and one person per machine, the job used to take five minutes' worth of human labor — one-twelfth of a worker-hour. Processing time and worker-hours were always lumped together. In fact, however, processing time in this example is four minutes and human labor time only amounts to one minute. But the overall process still takes five minutes. If a worker does his part in one minute and then loafs around for the remaining four minutes, he ought to be able to handle a different machine every minute, for a total of five machines.

No matter where you go in the world, confusion persists over processing time and processing worker-hours. When I see places where workers sit down for a smoke when parts begin to feed into machines, I recommend enhancement of

the labor force. Japanese workers do a good job of refraining from cigarette breaks, however. They don't figure they can take a few puffs just because the machine is doing the work. On the other hand, Japanese workers are not particular about what they do with that time. Since they are going out of their way to do something, however, we should have them work on the job at hand.

31

Rates of operability and operation

Another pair of terms that gets confused — partly because in Japanese they are homonyms — are "rate of operability" (*kadōritsu*) and "rate of operation" (*kadōritsu*).

The three Chinese characters with which the expression "rate of operability" is written show the literal meaning, "rate" (*ritsu*) at which something "can be" (*ka*) "moved" (*dō*). When a machine does not work because it is out of order, its rate of operability is poor. Although a poor rate of operability naturally entails a poor rate of operation, the rate of operability should be increased as much as possible; efforts should be made to bring it to 100 percent.

The rate of operation is another story, because it does not matter how much you run a machine if there is no work for it to do. You will earn no money. The rate of operation is determined externally by the availability of work. It is not worthwhile to have this rate so low that the burden of depreciation increases. Likewise, it is of no value to keep a machine running at full capacity when you cannot sell the product.

Put the other way around, to improve the rate of operability you should carry out rigorous preventive maintenance. Equipment must be in a state where it can be run on demand. At the same time, the rate of operability has nothing to do with machines that do not run because of the absence of work. If setup changes make a machine unavailable, however, then it stands to reason the rate of operation will rise when setup times are shortened.

The rate of operation varies with the current volume of work. There may be occasions which demand that a machine

be run overtime, say, at 120 percent. However, it is a good idea, when work falls off, either to lower the rate or to shut down the machine in order to save energy.

Confusing rate of operability with rate of operation — and assuming that both need to be increased — is like confusing processing worker-hours and processing time. It may be that a machine that should be running can't run because it's out of order. If so, maintenance should be carried out in such a way that the machine never breaks down. Maintain machines so they will always be available to run on demand. It only spells trouble if your machines are out of order and unable to run when you have enough work to run them at full capacity.

Rates of operability and operation are widely confused, and people talk about not having been able to earn a profit because of a poor rate of operation. It is essential to take a look at which of these two homonymous *kadōritsu*, however, was really at fault. The attitude that it is somehow wasteful not to run a machine that is in running condition is perhaps a source of the confusion.

The spinning and weaving business is in a slump at the moment and operations are being curtailed. We have cut back about 50 percent in comparison to our period of greatest activity. With the recent structural recession, we scrapped a considerable number of machines.

I opposed this move, arguing that it was important to be ready to run the machines if the opportunity arose, but we were able to get the government to pay us for scrapping them. With the money we received, we could buy state-of-the-art machines and with full automation could run them on a 24-hour basis. We then overproduced again. This is called "scrap and build."

This is fine when you really are expanding: messing around with low-performance machines is less desirable than scrapping those machines and bringing in the latest equipment. The industry will not go into a recession when the economy is booming and you cannot make money by throwing away old machines, so it seems to me to be more

sensible to increase international competitiveness by lowering costs and raising productivity.

At Toyoda Spinning and Weaving, for instance, we insist that our costs be lower than those in developing countries. If it gets to the point where we can't produce inexpensively, then we have to think about quitting. When a big spinning and weaving concern adopts that attitude, one would expect quite a few companies to quit the business. Perhaps if half the big companies drop out, the remaining firms would be able to run at full capacity. Even at full capacity, though, they may not be competitive with developing nations if their costs are higher.

You might raise productivity fivefold by running machines automatically for three shifts, but you cannot overproduce, because productivity will go right down again if you make too much. So the companies that are really going to survive are those that can make the specified quantities of items inexpensively.

There are no state-of-the-art machines at Toyoda Spinning and Weaving. My point is that we ought to get out of the textile business if we're unable to run our current machines with the same number of worker-hours as the latest, up-to-date equipment. All the same, a small variation in exchange rates can make our best efforts come to nothing. This complicating factor makes the textile business a difficult one.

And, of course, people want their wages increasd by 8 or 9 percent. Just increasing productivity by the same amount turns out to be a considerable task. People talk about basing wages on productivity, but the kind of productivity they have in mind usually involves direct labor costs only. Today, the more companies automate, the more indirect labor costs increase with respect to direct labor costs. This means that when a few people increase their productivity and ask for a commensurate wage hike, the majority of workers see their wages shoot up even though they had nothing to do with the change in productivity. It's all right, though, for salaries of staff members — including people in

indirect areas — to increase if we are talking about less than half of the productivity increase.

This is a strange trap because when experts talk about productivity — for example, in the spinning and weaving business — they think that all they need is a 10-percent increase in the direct output of spinning and weaving. And we are not just talking about spinning and weaving — all companies are like this. Yet it is nearly impossible for everyone to increase productivity 10 percent. It is difficult enough to increase direct labor output by 10 percent. There is no way tens of thousands or even thousands of people are going to raise their productivity by that much.

32

Production technology versus manufacturing technology

We make a distinction between production technology or engineering (*seisan gijutsu*) and manufacturing technology or engineering (*seizō gijutsu*). Manufacturing technology involves how things are made, while production technology is concerned with how that can be achieved.

There is an old saying to the effect that *fools and scissors should be handled with care*. Manufacturing technology uses those scissors and concerns itself with how things can best be cut. Production technology, on the other hand, finds the right scissors for the job. For example, it would recommend fabric shears for cutting cloth or a special kind of shears for clipping off small branches.

Production technology studies these questions and also includes the development of the right scissors for a given job. Nevertheless, you may get the right scissors with production technology, but without manufacturing technology you won't cut anything very well.

As a novice, you might borrow a pair of sheet metal shears to cut sheet steel, but that does not guarantee you will be able to do the job. Yet someone skilled in the use of sheet metal shears can cut thin sheets of paper or anything with them. If it came right down to it, he could even shave with them.

Going back to our story about cameras, we tend to think that things inevitably turn out well as long as we are working with good materials. In fact, we can't do a good job unless we have solidly mastered the use of those materials. We need to seriously study manufacturing technology, but here — as with the ratios of operation and operability — confusion arises.

The spread of computers brought with it the terms "hardware" and "software." But even before that, we were giving serious thought to the difference between manufacturing and production. Improvement (*kaizen*) moves ahead rapidly when you have a solid base of manufacturing technology. Manufacturing technology is what we used to call "shop technology" (*genba gijutsu*).

When I first visited the United States some 30 years ago, I was taken around at one point by a plant engineer. His business card identified him as a general plant manager and he was very knowledgeable about what happened on the shop floor. He interacted easily with the shop foremen. If I asked him something he did not know himself, he would immediately go and ask a foreman. As I returned to Japan, I remember feeling that such technicians were essential.

I believe plant engineers ought to have this shop know-how. The expression "plant engineering" is used today, but apparently it does not refer to shop technology. Plant engineering in Japan seems somehow to involve engineers, but wouldn't it be preferable to have more in the way of shop technology?

It would be nice if people at a given company — at Toyota, for instance — were people who made good manufacturing technicians. It was pointed out to me once that although there are many fine production engineers at my parent plant, there are no manufacturing engineers. I realized that the person who told me this viewed what we had been calling shop technology as manufacturing technology. We began shortly to use the expression "manufacturing technology."

In the same vein, we would like to define manufacturing technology to include plant engineering. Generally speaking, many production engineers seem removed from the workplace. In the entertainment world, too, there are performers who cut paper with scissors and have no personal contact with the scissor-makers. From the scissor-maker's point of view, it is not enough just to learn about scissors that will cut paper. He or she should know something about

other kinds of scissors: fabric shears and scissors suited to cutting silk. Before, people got by with multipurpose scissors. But even then, sometimes clippers were more convenient, while at other times, scissors with handles sufficed. These things sometimes have to evolve gradually.

Years ago I made myself unpopular by suggesting to people in Toyota's production engineering department that they were "catalogue engineers." "You can't," I told them, "just look at catalogues and then tell us that 'this machine looks good' or 'we could double or triple productivity with that machine.' We need machines that you guys have developed yourselves."

Thus, within a single enterprise, manufacturing technology and production technology ought to be totally integrated. Suppose you want to put out a new product. When you deal with new materials or the like, you must decide what equipment to use and what processes are needed to make the product. In general, the production technician is in charge up to this point. The manufacturing technician's role encompasses process improvement and equipment improvement once the product is being made.

The distinction here is crucial — but some people never understand it.

33

The cost-accounting trap

When we want to evaluate something, we usually end up doing some kind of cost accounting. There is nothing wrong with cost accounting, but it sometimes leads top executives to faulty judgments.

When told that the purchase of a new machine will definitely pay off or cut production costs, an executive decisionmaker sees that no mistakes have been made in the numbers and is then inclined to buy the machine. Once the purchase is made, however, a machine that might pay off at 10,000 units may not pay off at all with an order of only 5,000 units. What comes out in the final calculations will depend on various preconditions: how many units are needed, under what circumstances will the machine pay off, will it be generating profit two years from now?

A machine becomes fantastically expensive when we fail to sell the expected number of products. We like to make calculations come out favorably for machines we really want. Afterwards, we can make all the excuses we want about inaccurate demand forecasts, but no one is going to compensate us for the mistake.

Cost accounting is another problem area where you can't know which alternative is preferable until the results are in. For example, depreciation is figured in so that if a machine is amortized in 10 years, you scrap the machine after those 10 years and purchase an up-to-date one. In cost accounting, amortization costs, in fact, become internal reserves. When you have gone to all the trouble to set up those internal reserves, it seems pretty extreme to say you should throw away equipment just because it is amortized. Eventually that will leave you with no internal reserves at all.

Indeed, the production technology experts in big, profitable companies will tell you that fully amortized machinery is decrepit and that efficiency will increase if you buy the latest machines. In reality, they are working under the illusion that they can buy new machinery with money from internal reserves. The truth is, though, that accountants just cannot bring themselves to accept that having internal reserves means current machines can now be used for free. They do not understand that once you have amortized equipment, the rest is profit.

When production or the economy is expanding, they advise us, within the framework of cost accounting, to invest in equipment. But it would be a big mistake to stick to the same philosophy in times when, as now, overproduction would be disastrous. They tell us instead that if we produce cheaply with amortized equipment and bring in a lot of money even with no increase in sales, we will just lose it in taxes. The thing to do is get rid of the old equipment and acquire new machines that will not bring in such large profits.

Rather than use specialized machines, if most of your equipment consists of versatile machines adapted to specific applications or multipurpose automated machines, then when new parts come along, slight modifications will allow you to use the same equipment you already have. In this case, you really do have "free," fully amortized machines that will continue to bring in profits even as new products show up.

The idea of "versatile customized machines" gives headaches to designers because building satisfactory equipment of this sort is not easy. Even so, a glance at recent newspaper advertisements reveals that some equipment manufacturers are using this very phrase to describe their machines.

It was right after the first shock of the oil crisis that I told my people to build versatile customized machines. This varies according to the industry involved, but certainly for us at Toyota and all the auto body manufacturers, more than half of capital investment goes into making dies. At Toyota, die production amounts to over 60 percent of capital investment.

34

The monaka *system*

Press dies simply have no versatility. You use one for a while and then have to throw it out when a design change is made.

In the automobile business, every time the shape of a car changes, the body makers have to make hundreds of huge new dies. We can amortize them, but since they contribute nothing to internal reserves or anything else, the process always puts the squeeze on us. Presses themselves are quite versatile, however. I felt we had to come up with a way to make dies adaptable to specific applications, so I ordered the development of *monaka* (sweet bean paste bun) dies.

The outer wrapper of a *monaka* does not spoil easily, so it can be made in advance and set aside. Suppose you have been asked to make several hundred *monaka* for a picnic somewhere. What is there to do but cook the bean paste filling the night before? You can go ahead and make the outside pastry wrapper whenever you have the time. When the filling is cooked, just stick it in the wrapper and you're done.

But suppose you slacked off thinking there was no work and didn't make wrappers because there were no orders. And then suppose some new law resulted in a sudden deluge of orders for *monaka*. You would have to make the wrappers as well as the bean paste and you would never finish in time.

With dies, too, the wrapper — or outside shell — can be used for anything. Things would go relatively quickly if the middle part were hollowed out and you could perform a changeover just by inserting the "filling." This was the idea we set out to put into practice.

The problem was that conventional dies are made in one piece. Because their outer configurations were of three kinds, we had to distinguish three types: large, medium-sized, and small ones. First we cut out the center sections and carefully set them aside. Inserting old dies inside kept our costs down. These modifications turned out to be a great deal of trouble, however, and even after five or ten years we had not yet converted all the dies.

The *monaka* system suggests *anmaki*, another kind of pastry in which bean paste is rolled up inside. We gave this idea a shot, too, but it failed. With *anmaki*, you make the bean paste first. When a customer comes in, you pour udon flour batter onto an iron griddle, put in the bean paste, and roll it up. In other words, you are doing things in the reverse order. Not only can bean paste go bad, but it is the most expensive of the ingredients. The cheap part is the outer wrapper and the rest. You make a lot of *anmaki* without knowing how many will sell and you end up letting the buns go bad if customers vanish.

Indeed, new dies must be made by a certain time. This is why standards for the exteriors should be set in advance. That way, you can take out the center portions if it turns out that you do not need the dies. At about the 30,000th unit, you finally reach the point where all you have to do is make the "filling." This, of course, takes quite a bit of time.

This approach gives versatility to dies as well, and future capital investment in dies will be much less because only the "fillings" are specialized. If you make dies a little on the large side, you can still use them if the next parts to be produced are slightly bigger. On the other hand, by making dies too specialized and eliminating all excess bulk, the dies become impossible to use if parts increase in size. This versatility is important, and versatility is something the Toyota production system continues to develop.

It has often been observed that business management calls for three elements: people, things, and money. In the final analysis, however, a business cannot fulfill its responsibility to society unless it continues to show a profit. And how

does a business make profits? Well, for one thing, there's the way it *sells* its products — earning money through commercial transactions. Similarly, the skillful *use* of money can bring profits to a business. The final element is lower costs.

As long as it generates profits, selling is the most painless method of the three, because with a high selling price, sales will increase profits even without lowering costs.

This means, I suppose, that if you put clever business people at the top and they continue to turn a profit, the workplace can breathe easy. But the time for clever salesmanship is over. When financial pressure builds, lowering costs cannot be accomplished all of a sudden. Cost reduction must be a prime concern all the time. This is the most important workplace issue for technical people. Even reducing inventory is ultimately aimed at taking pressure off the financial side of things.

For example, cutting work-in-process or inventory by, say, $200 million makes money available to accounting. If accounting does a good job of investing the money in securities or the like, then some percentage of that $200 million will come in as cash. The point is that if the money is sitting on the shop floor in the form of physical objects, you are going to have to go out and borrow money to pay for things like materials and electrical power. The gap between the relative benefits of the two approaches is substantial.

It is hardly desirable to have to pay 10 percent interest to a bank and only be able to pay 5 percent to shareholders on money that, if handled wisely, could just as well be paid out in dividends. Here again, if the workplace does its part to cut back on inventory, the amount saved can have a substantial impact when made available to accounting. Dividends may double, or if increased profits mean paying higher taxes, then they will contribute to the nation as a whole.

Everyone has the impression that accounting is responsible for cost-cutting, but if you think about it, accounting is entirely incapable of reducing costs.

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Only the workplace can cut costs

I gave some advice recently to a personnel manager:

"When folks from the shop come to you saying they want 100 people, send them 10. They'll manage to find some way or another to accomplish what they have in mind. So if they come wailing to you saying that they absolutely need those 100 people, don't argue about it. Just send them 10 people. That way, personnel will have cut its costs by 90 workers' worth."

The same thing goes for accounting. Suppose inventory has been reduced on the shop floor and that the money goes into the safe. Its presence means that a profit of several percentage points can be generated through the use of capital. Thus, I say, even accounting can cut costs by the wise use of money saved in the workplace. It is fine to give accounting a share. You can tell people that the firm won't make any money — or that it will lose money — unless they make a certain quota, and you can instruct the manufacturing or planning division to cut costs by *X* percent.

But quotas will bear no fruit without the cooperation of the departments involved. Thus, people on the shop floor must be fanatics about cost reduction as though cost-cutting were impossible outside the workplace.

Let me caution everyone about the notion of "cost information" (*genka chishiki*), because it comes at the expense of "cost consciousness" (*genka ishiki*). As far as I'm concerned, we can do without the former. In fact, I don't even plan to keep the phrase in my vocabulary.

Calculations based on cost information will lead to production that is sometimes cheap and sometimes expensive.

What I am trying to say is that nothing is more foolish than taking things that cost consciousness could easily determine — calculating capital investments and so on — and then concluding that such-and-such will pay off or that such-and-such approach is the least expensive.

It is a crazy arithmetic that figures the effects of rationalization in terms of how many percentage points more rational things get every month. You may not see any effect of rationalization at all. Or you may see a sudden surge if production increases and that increase is accomplished without additional equipment or people. In some cases, results will lag most where small improvements (*kaizen*) are accumulated one by one. But even if you give up on gradual improvement and bring in computers and robots, you will be unable to use them right away. This is why those daily accumulations must never be abandoned.

From 1955 to around 1973, we could sell as much as we produced. During this period, the effects of rationalization showed up quickly. Either we got away without increasing manpower or else machine-operating rates improved and equipment became cheaper to run. As a result, the effects of rationalization were legion.

In an age of slower growth, however, considerable tenacity (*shinbō*) is called for. Whenever people want to have results acknowledged or the numbers turn out right, they get impatient and end up focusing exclusively on this month or next month. This is entirely unacceptable. We are in trouble if we cannot be tenacious. Recently, the word "tenacious" has come to be used even in the world of sports. One hears, for instance, that the golfer, Aoki, is a "tenacious" player. In sports, as in business, tenacity can be pivotal — once a certain basic ability is there, that is.

As long as disparities in ability exist, we hear about one contestant's "having the edge" over another or about "top" players. But as the gap in skill or technical mastery narrows, tenacity becomes the critical factor. Despite unfaltering tenacity, even Aoki loses sometimes. On the other hand, if he were to get impatient, he would end up out of the running.

America's General Motors and the United Auto Workers (UAW) constitute a formidable enemy when they are so tenacious as to be willing to accept pay cuts. You would have quite a problem suggesting wage reductions in Japan! Look at the National Railway. The fight to raise salaries goes on in spite of their huge deficits. Without tenacity and perseverance on both sides, a private-sector company in the same situation would be past helping.

Fundamental to the performance of work is the importance of adhering to chosen procedures. This adherence is by no means easy — even with a kanban system. It is easy to say the words, but actually doing it is another story. It is important, then, to ask why we can't stick to our chosen procedures. Young people seem to think the word "chosen" (*kimerareta*) sounds odd. They assume it means a decision by somebody higher up and wonder why they should not be able to do the deciding themselves. This is what *kaizen* (improvement) is all about. First, try the chosen procedure. Otherwise, you won't know whether it's good or bad. Then, if you are unable to adhere to what has been decided, you should assume there is something wrong with the procedure in question.

With kanban, therefore, not being able to do something as specified implies that something is wrong with the way the kanban are moved along. When this happens and someone suggests a new method, the new approach must be adopted immediately. Thus, even though a procedure may be specified in advance, in the end it is the worker who chooses how to proceed.

It is a mistake to interpret "chosen" as meaning "set by someone higher up." This once was common in plants. If a newly arrived foreman — or anyone at about that level — suggested a different way of doing things might be better than the current method, he or she was thought to be out of line and the idea was dismissed.

If a particular device or anything else is changed in a certain way, that *change* is the improvement — even though some changes are for the worse. Any change for the worse

has to be corrected right away. And that means *improved* and not simply returned to the original state.

Although we use what are called "standard operations," the standards involved must be changed constantly. You should never think that standards are perfect. Standards are a kind of basis for improvement. If something deteriorates, then the change is for the worse; if it gets better, then it is an improvement. Human beings discover which is which by chance, so it would be silly not to keep changing things.

Whenever we begin by looking for the very best procedure for a standard operation, the standard operation is never forthcoming. Better to write down the procedure as it is carried out now. Then if you make it better, you have improved it. Otherwise, trying to get the perfect method from the first will quash the desire to improve. Indeed, setting up poor standard operations is one trick for promoting a desire to improve. Of course, you don't want to be too haphazard about it. Without some kind of standard, praising someone for an improvement will be meaningless because there will be nothing to which you can compare the new procedure. You have to start by establishing a plausible standard and then improve it by gradually drawing out new ideas.

Be careful about using the passive voice when you talk about following chosen procedures. Saying "procedures that have been chosen" may make it sound as though there is some sort of coercion involved. Emphasizing the notion of "choosing" is better, for there is no implication of who is making the choice — the worker himself has the authority to choose, for instance. There is no question of anything like coercion when an individual adheres to procedures chosen by him or herself.

You should start off by following standard operations. As you proceed, you can then expect suggestions for improvement to arise from aspects of the operations that are tedious or that could be made easier or otherwise improved. At that point, you should incorporate those new ideas into new standards.

In the old days, we used to make standard operations manuals available throughout the plant. As the pages discolored over the course of a year, certain people clung slavishly to the manuals. I would accuse them of having stolen a year's wages. What did they come to work for every day, anyway?

Something is wrong if workers do not look around each day, find things that are tedious or boring, and then rewrite the procedures. Even last month's manual should be out of date. At Toyota, we started out by providing standard operations charts and having people fill them out and date them. These would then fuel the anger of any foreman who saw that a worker had been slacking off for a month.

"Don't be ridiculous!" a foreman might say. "It doesn't take a month or two to write up a standard operations chart! And don't write them up while you're in bed — write them up on the shop floor when you have your eyes open!"

36

The best
standard times
are the shortest

Everybody gets time studies wrong when it comes to standards. They perform an operation 10 times or so and then take the mean value. This is the worst way to go about things.
something 10 times, each time a little differently. Some people don't know too much about it and simply learn to use a stopwatch and some codes. So they perform the operation 10 times and set a standard operation on the basis of a mean value. This is utter nonsense. If you are going to run the operation 10 times, take the shortest time as the standard. Some people say this makes the standard too stringent, but what is stringent about it? Whatever method takes the shortest time is the easiest.

Even if you follow the same procedure 10 times over there will be differences. The method that takes the least time will be the easiest one, so you need to analyze why it took a few minutes or a few seconds longer the other times. The operation must not have run as smoothly as it might have, or perhaps it took more time because a mistake was made somewhere. In any event, I tell people nothing about setting standard times is so difficult that it warrants using the mean time.

Suppose on one run the worker dropped a nut and picked it up. You might think that catching such nuts halfway down would take less time than if they were to fall all the way, but I urge people not to make the problem more difficult than it is. Why does the worker grip the nut in such a way that it can fall in the first place? Is there no more secure way of grasping nuts? This approach will lead to the shortest operation times and the easiest movements. For some

reason, when the same task is performed every day, there seems to be a general tendency to make allowances for occasional decreases in work.

When you establish standard times, leave no breaks at all for workers to attend to personal hygiene. Some people argue that this departs too much from reality, and they insist on figuring in time for trips to the bathroom or for setup changes. But this is where managers can be really very sneaky. If people have to go to the bathroom, they say, stop the line and go. If workers want to break for a smoke, let them smoke. But while they are having their smoke, they should have the foreman or someone else come over and cover for them. And they should give notice when they are going to the bathroom. Even if someone is not feeling well and has to make frequent trips to the bathroom, having him come in to work and go to the bathroom four or five times in the course of the morning is preferable to having him stay home.

If you were to take a mean value and say that a worker will go to the bathroom once every two hours — or even twice if he is not feeling well — you would be telling those who didn't want to go at all to go anyway. Breaks of this sort are to be avoided at all costs. Everyone thinks in terms of mean values, but in the real world there are no such things as mean values.

Here's a trivial little episode. A long time ago, if I were to go to a machine shop or some such place and observe operations there, I would see people doing nothing but going to regrind machine bits. They would not measure time as long as anyone was watching, because they had it in their heads that they didn't grind bits very often. I used to get a lot of complaints like this.

Someone who once went to make time measurements of a carpenter's work could not measure anything because the carpenter spent the whole time sharpening a plane. After two or three swipes with the grinding stone, he would shake his head and grind some more. In this instance, it was utterly meaningless to have the task in question timed by someone unfamiliar with performing the work himself.

In summary, if you are going to measure something a number of times, I suggest you take the shortest time. The important thing is to figure out why you can't perform the task in the minimum time and then teach others how to avoid the same problem.

About the Author

TAIICHI OHNO WAS born in Dairen (Port Arthur), Manchuria, China, in February 1912. In 1932, after graduating from the department of mechanical engineering, Nagoya Technical High School, he joined Toyoda Spinning and Weaving. In 1943, he was transferred to the Toyota Motor Company where he was named machine shop manager in 1949. He became Toyota's director in 1954, managing director in 1964, senior managing director in 1970, and executive vice president in 1975. Although he retired from Toyota in 1978, Mr. Ohno continues as chairman of Toyoda Spinning and Weaving. He resides in Toyota-shi, Aichi-ken.

This book first appeared in Japan in May 1978 and reached its 20th printing in February 1980. Productivity Press's 1988 edition is the first printed for the English-reading public.

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